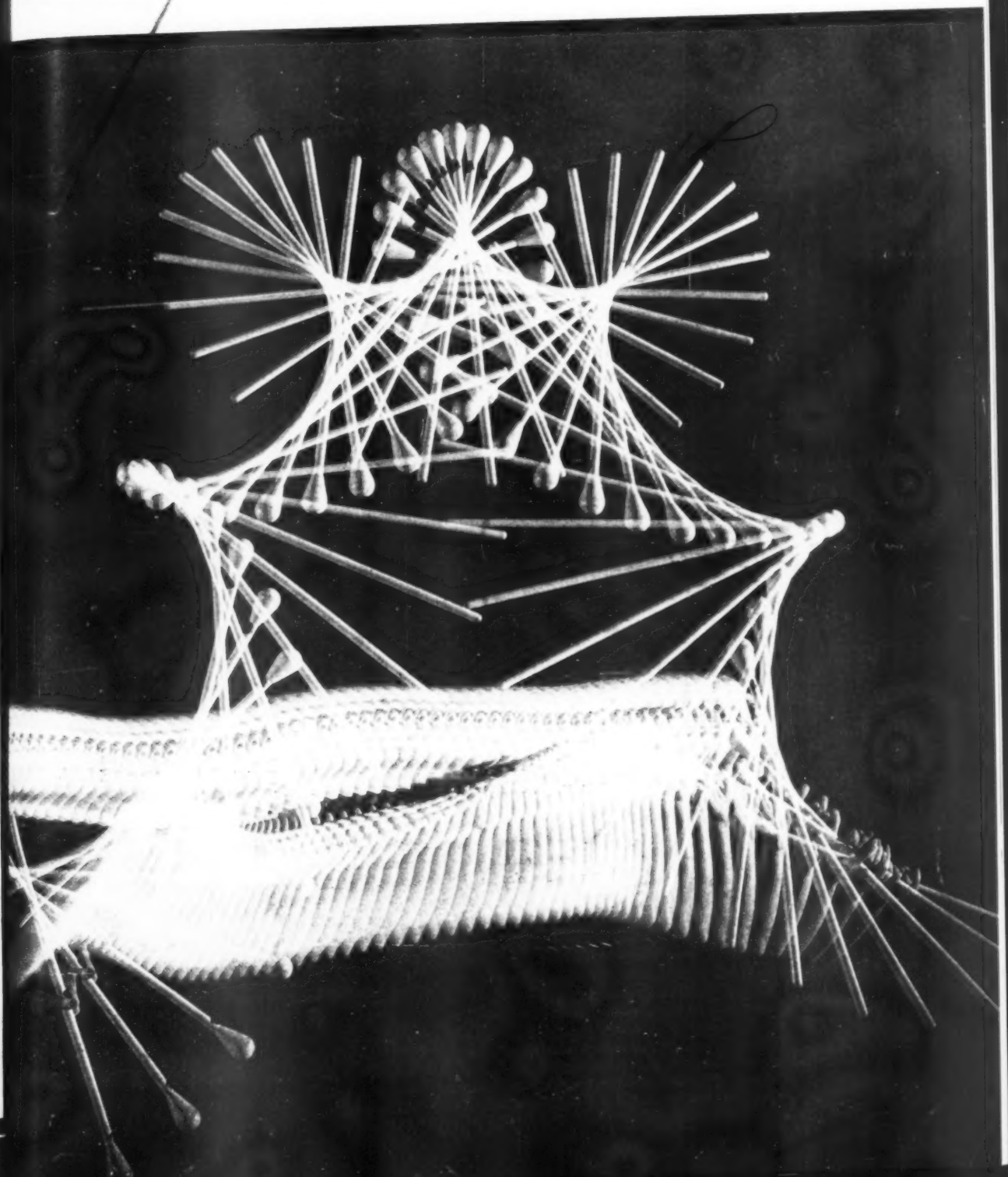
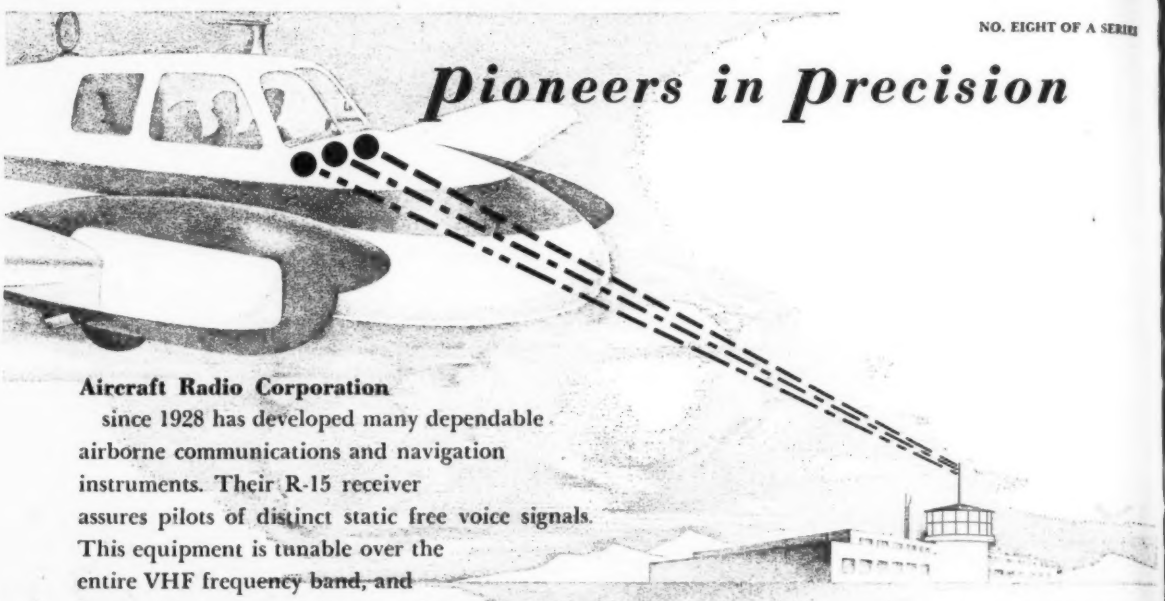
TECHNOLOGY REVIEW

April 1953



NO. EIGHT OF A SERIES

Pioneers in Precision

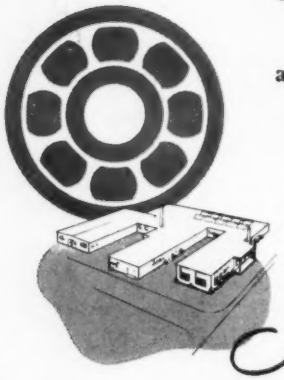


Aircraft Radio Corporation
since 1928 has developed many dependable airborne communications and navigation instruments. Their R-15 receiver assures pilots of distinct static free voice signals. This equipment is tunable over the entire VHF frequency band, and its controls require minimum cockpit space.

Miniature Precision Bearings
contribute the precise operational characteristics necessary to efficient instrument function under unusual operating conditions. This R-15 receiver is designed for long, trouble-free operation under extremes of humidity, temperature and vibration. Similar and other unusual problems present in thousands of vital equipment designs are being solved with **MPB** ball bearings.

More than a million **MPB** ball bearings have been installed in many unusual and distinctive devices. Originators and pioneer developers of ball bearings in this size range (1/10" to 5/16" O.D.), **MPB** has, for more than twenty years, supplied ultra quality bearings to discriminating users. Exclusive and exacting production and inspection procedures assure the type of quality ball bearing which permits installation in control and recording instruments of highest possible performance standards.

The most extensive engineering knowledge in miniature ball bearing application is available to you — as well as catalog and survey sheet TR4.



Continued expansion in production facilities has enabled us to enlarge the scope of service to our clientele. We would welcome the opportunity of including you.

Miniature *precision* Bearings
Incorporated MPB Keene, New Hampshire

"Pioneer Precisionists to the World's foremost Instrument Manufacturers"

save
space
weight
friction

More *go* per gallon

Your automobile motor has more than 200 parts. They require close to 900 precision grinding operations.

Your motor's crankshaft, for instance, must be dimensionally true within .001 inch. It gets this accuracy from Norton ALUNDUM* grinding wheels on high production Norton grinding machines. The finishing touch is given with a special Norton lapping machine, using Behr-Manning Lightning ADALOX* coated abrasive. Such true, smooth surfaces make parts fit . . . cut friction . . . give you "more go per gallon."

The automotive industry is only one of many industries which rate Norton and Behr-Manning products essential to their production. As the world's largest manufacturers of abrasives and abrasive products, Norton and Behr-Manning keep seeking better ways to help *all* industries make better products.

NORTON makes abrasives, grinding wheels, refractories, Norbide grain and molded products, grinding and lapping machines, non-slip floors. Norton Company, Main Office and Works, Worcester 6, Massachusetts.

BEHR-MANNING makes abrasive paper and cloth, oilstones, abrasive specialties, Behr-Cat brand pressure-sensitive tapes. Behr-Manning Corporation, Division of Norton Company, Troy, New York.

Plants, Distributors and Dealers the world over

J. HOWARD BAKER is General Superintendent of the Behr-Manning Abrasive Division. His exceptional ingenuity in 34 years' service has resulted in many outstanding improvements in the quality of Behr-Manning products.

HARRY O. ANDERSON has completed 51 years with Norton. Now Chief Grain Inspector of the Abrasive Division, he has originated and patented many improvements in abrasive processing and quality control.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON

BEHR-MANNING

Making better products to make other products better

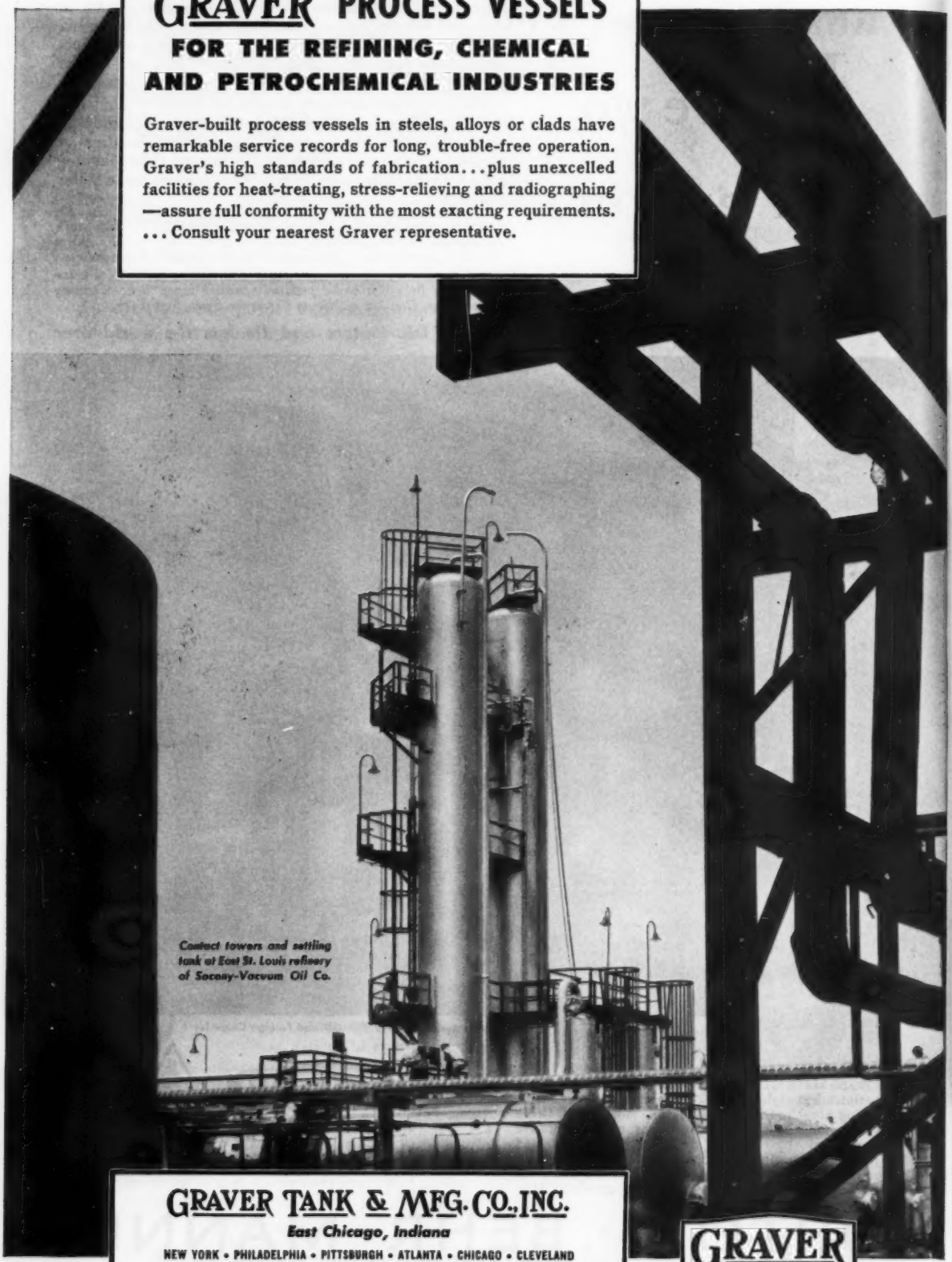
NORTON · BEHR-MANNING

THE TECHNOLOGY REVIEW, April, 1953, Newsstand Edition, Vol. LV, No. 6. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter December 23, 1949, at the Post Office at Bristol, Conn., under the Act of March 3, 1879.

GRAVER PROCESS VESSELS

FOR THE REFINING, CHEMICAL AND PETROCHEMICAL INDUSTRIES

Graver-built process vessels in steels, alloys or clads have remarkable service records for long, trouble-free operation. Graver's high standards of fabrication...plus unexcelled facilities for heat-treating, stress-relieving and radiographing —assure full conformity with the most exacting requirements. ... Consult your nearest Graver representative.



Contact towers and settling tank at East St. Louis refinery of Socony-Vacuum Oil Co.

GRAVER TANK & MFG. CO., INC.

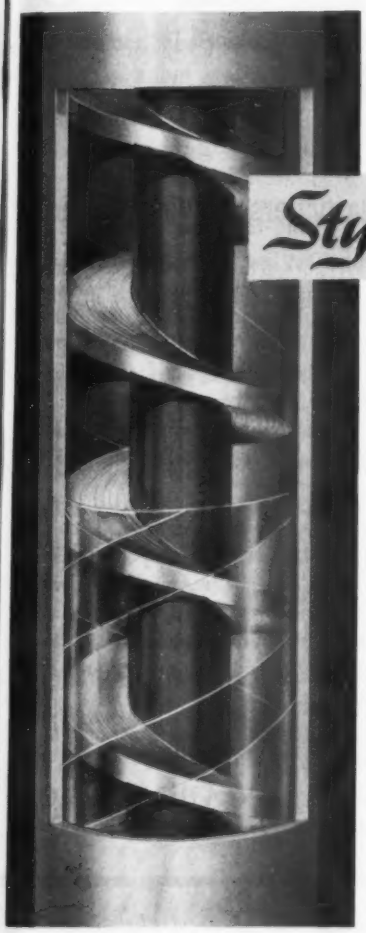
East Chicago, Indiana

NEW YORK • PHILADELPHIA • PITTSBURGH • ATLANTA • CHICAGO • CLEVELAND
DETROIT • HOUSTON • CATASAUQUA, PA. • SAND SPRINGS, OKLA. • CASPER, WYO.

GRAVER

TWO REVOLUTIONARY NEW CABLE DESIGNS

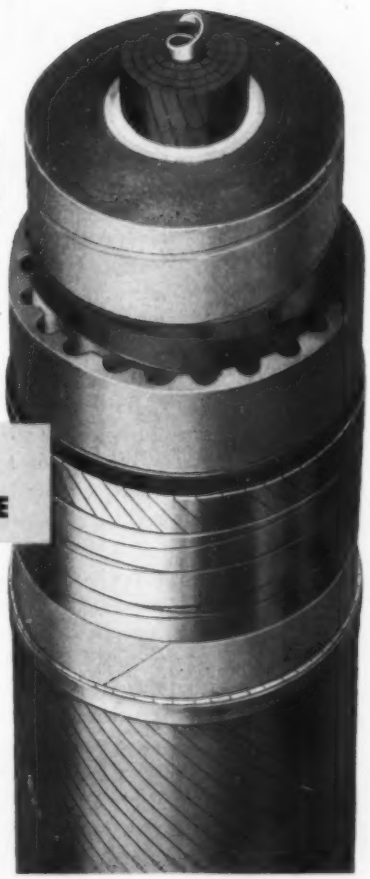
Available to American Cable Users—Illustrate International Scope of Phelps Dodge Research and Technical "Know-How"!



Under arrangements concluded with leading European cable designers, Phelps Dodge Copper Products Corporation offers U. S. cable users:

Styroflex COAXIAL CABLE

developed by Felten & Guilleaume, Cologne, Germany. The strong, semi-flexible aluminum sheathing on this cable opens possibilities for many new and interesting uses.



400 KV OIL-FILLED POWER CABLE

designed by Les Cables de Lyon, France. This cable is presently in service in Sweden.

These new cables exemplify Phelps Dodge's policy of supplementing its own broad research with the latest foreign developments in cable research and manufacture. This international "know-how" is one of the reasons why Phelps Dodge enjoys a wide reputation among engineers for the finest in modern power and communication cables.

PHELPS DODGE COPPER PRODUCTS CORPORATION

40 WALL STREET, NEW YORK 5, N. Y.

Cabot *First* with All-Decyl Plasticizers, too!

Cabot Manufactures a Complete Range of Cabflex Plasticizers for Vinyl Plastics

The world's largest manufacturer of carbon blacks, with a seventy-year background of experience in producing raw materials for industry, is renowned today for a variety of top quality products, including a complete range of plasticizers.

Plastics manufacturers, confident of the extra quality and uniformly superior product performance for which the Cabot name is famous in other fields, specify Cabflex plasticizers and Cabot coloring blacks whenever they want best results.

Cabot's Plasticizer Division gained prominence within the industry last year when it announced expansion of its production and research facilities. In August, Cabot announced a "first" for the plasticizer industry with commercial production of the world's first all-decyl plasticizers. Cabflex DDA and Cabflex DDP are a welcome addition to the Cabot line. They offer the vinyl compounder the usual combination of low volatility, low temperature flexibility and high permanence at competitive prices. Cabflex DDA imparts permanence, low temperature performance and minimum changes in drape and flexibility over wide temperature ranges. Cabflex DDP is recommended for use with standard plasticizers to improve quality, add permanence, and give excellent flexibility over wide temperature ranges.

Today, the Cabot Companies offer a complete range of plasticizers, quality controlled throughout every step of manufacture . . . tested in modernly equipped, competently staffed research laboratories . . . backed by the Cabot reputation for superior quality and reliable performance.

For technical information and for samples, address: Plasticizer Division

GODFREY L. CABOT, INC.
77 FRANKLIN STREET, BOSTON 10, MASS.

Cabflex Di-OP	*di-iso-octyl phthalate*
Cabflex DCP	*di-capryl phthalate*
Cabflex DDP	*di-decyl phthalate*
Cabflex Di-BA	*di-iso-butyl adipate*
Cabflex Di-OA	*di-iso-octyl adipate*
Cabflex DDA	*di-decyl adipate*

CABOT
Since 1882

CABOT for CARBON BLACKS • PLASTICIZERS • PINE TAR • PINE TAR OIL
DIPENTENE • SOLVENTS • SOFTENERS • COKE • WOLLASTONITE • CLAY
NATURAL GAS • NATURAL GASOLINE • OIL PUMPING EQUIPMENT • CHARCOAL

Down the track comes the 5:22 loaded with homeward-bound commuters. She's whistling as she comes calling for the switch that will put her on the outbound track as she leaves the yard limits. Silently and dependably the switch swings into position and the 5:22 has "gone that-a-way."

* * *

How do trains get on the right track? By means of vital relay boxes like the one illustrated here. Relay boxes that are wired with long-lasting, dependable Anhydroprene Case Wire. They offer exceptional resistance to water, moisture, oil, grease, acids and flame. They have no fibrous braids to fray or rot.

The light weight, small diameter and greater flexibility of Anhydroprene Case Wires make them ideal for relay wiring installations. They are easy to handle and terminate.

Specify and get Anhydroprene Case Wires for economy, quality and dependable service. Ask your nearest Simplex railroad representative for more complete information or write to the Railroad Department at the address below.

Simplex WIRES & CABLES

SIMPLEX WIRE & CABLE CO., 79 Sidney Street, Cambridge 39, Massachusetts

CUTTERS

that give you more clean cuts per dollar

Every cutter in the broad Brown & Sharpe line is carefully designed and manufactured to lower your *real* cutter cost . . . give you more smooth, clean cuts per dollar invested. Complete selection of types and sizes to improve milling efficiency on any job. Write for illustrated Catalog. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

BUY THROUGH YOUR LOCAL DISTRIBUTOR

Brown & Sharpe

RAYTHEON

your prime source of information and assistance right down this list

JUNCTION AND POINT CONTACT TRANSISTORS

GERMANIUM DIODES

SPECIAL PURPOSE TUBES:

Miniature
Subminiature
Rugged
Reliable
Nucleonic
Rectifier
Transmitting
Voltage Regulator
Voltage Reference

SPECIAL TUBE AND TRANSISTOR APPLICATION ENGINEERING SERVICE AT

Newton, Mass.	Bigelow 4-7500
New York	WHitehall 3-4980
Chicago	NAtional 2-2770
Los Angeles	Richmond 7-5524

RAYTHEON MANUFACTURING COMPANY
SPECIAL TUBE SECTION
55 CHAPEL STREET, NEWTON 58, MASS., Tel. Bigelow 4-7500

THE TABULAR VIEW

Today's Aeronautics.—Originator of the Institute's Course in Aeronautical Engineering, pioneer aeronautical engineer, administrator, educator, and chairman of the National Advisory Committee for Aeronautics, PROFESSOR JEROME C. HUNSAKER, '12, has witnessed the entire span of man's successful attempts at flight, and has made outstanding contributions to man's progress in this field. From his vast experience in aviation, Professor Hunsaker discusses the "Social Aspects of Aeronautics" (page 309). His Review story, delivered at the Eighth International Congress for Theoretical and Applied Mechanics last summer in Istanbul, is based upon the 28th series of Terry lectures, delivered at Yale University and published in book form as *Aeronautics at the Mid-Century* in 1952 by Yale University Press. Last summer Professor Hunsaker retired from his post as head of the Department of Aeronautical Engineering at M.I.T. which he established in 1914.

Science and Religion.—A mathematician's point of view is reflected in the essay (page 314) by PROFESSOR EMERITUS H. B. PHILLIPS of the Department of Mathematics, on science and religion. Defining good as that which accelerates progress, Professor Phillips concludes that world morals may be expected to improve steadily, and that, in a statistical sense at least, right makes might. After graduation from Erskine College in 1900, Professor Phillips received the Ph.D. degree from the Johns Hopkins University in 1905. He joined the M.I.T. Department of Mathematics in 1907, becoming head of that Department in 1935. Dr. Phillips is author of more than a score of books and scientific papers, chief among which are "Notes on Einstein's Theory of Gravitation," "Faraday's Law as a Basis of Electromagnetic Theory," and a textbook entitled *Vector Analysis*.

Health Enterprise.—A major aim of modern medicine is to prevent, as well as to cure, maladies. An unusual phase of such preventative medicine has been in operation at M.I.T. since 1947 and is described (page 315) by DR. HARRIET L. HARDY, Assistant Director of the Institute's Medical Department. In addition to being in charge of the Occupational Medical Service at M.I.T., Dr. Hardy has been chief of the Occupational Medical Clinic of the Massachusetts General Hospital since 1949, and is consultant to the Atomic Energy Commission, the Massachusetts Division of Occupational Hygiene, and the Atomic Research Center at Ames, Iowa. Dr. Hardy is a graduate of Wellesley College, took the M.D. degree from Cornell University Medical College, and trained at the Philadelphia General Hospital.

Project Glacier.—Bringing together his knowledge of engineering, geology, and history in his article, "Project Glacier" (page 319), E. H. CAMERON, '13, poignantly describes the essential and prosaic task of our forefathers in clearing their fields and enclosing them with stone fences. Mr. Cameron has had a wealth of professional experience in civil engineering since his graduation from the Institute in 1913. For the past decade, Mr. Cameron has been head of the Technical Publications Division of Jackson and Moreland, Boston firm of consulting engineers. Mr. Cameron is no stranger to Review readers; his first Review article appeared in 1932, and for about 10 years he has averaged one article per year.

CONTINENTAL'S PROOF BOOK

E. J. GIVENS

Pennsylvania State College, B. S., 1944. Joined New York Wire Cloth Co. in 1948 as Industrial Engineer and became Purchasing Agent in 1950. Secretary of York Purchasing Agents' Assn.; member of National Assn. of Purchasing Agents, Purchasing Agents Assn. of Phila., and Society for Advancement of Management.

Incorporated 1892

NEW YORK WIRE CLOTH COMPANY

441 EAST MARKET STREET
YORK, PENNSYLVANIA

GENERAL OFFICES:
NEW CANAAN, CONN.

February 11, 1953

Continental Screw Company
New Bedford, Massachusetts

Gentlemen:

As manufacturers of a new kind of product--the Durall aluminum tension screen--we have been in an excellent position to appreciate Continental Screw's quality and service. For instance, we must have a screw that even a housewife can drive, and with a head large enough to seat properly in our screen clamp bracket. The screw that you designed for us has more than met our specifications.

Another feature that has resulted in additional sales appeal for our product is your method of fastening our screws on a tape, which has been pre-printed with our Durall brand name. This tape has proven a very convenient method of insuring that the exact number of screws reaches each customer.

Over a period of twelve months, our production schedules fluctuate, but whenever this happens you respond promptly with every possible effort to keep our line operating. We want you to know that this type of performance rates very high with us.

These extras, plus a top quality product, have given Continental the number one spot on our vendor list for screw requirements. It has been a pleasure to work with you during the past and earnestly hope this same association will continue for many years.

Sincerely,

E. J. Givens

E. J. Givens,
Purchasing Agent

You too can count on Continental.©

CONTINENTAL SCREW COMPANY INC. 1904

Manufacturers of HOLTITE Fastenings For Every Purpose

CONTINENTAL SCREW COMPANY, NEW BEDFORD, MASS., U.S.A.

Curtis Sets Standards

The meticulous standards set by Curtis, in selection, heat treating, strength, accuracy, tolerance, concentricity and smoothness, surpass the Class I specifications of the U.S.A.F.

CURTIS UNIVERSAL JOINTS

As a result, Curtis standards — and Curtis Universal Joints — are accepted and used by every branch of the Armed Services.

ONLY CURTIS OFFERS ALL THESE ADVANTAGES

Availability — 14 sizes always in stock; bored or unbored hubs. 6" hub diameter joints or special machining to specifications.

Simplicity—fewer parts, simpler construction.

Government Tests — complete equipment for government tests in our plant.

Not sold through distributors; write direct for free engineering data and price list.

CURTIS UNIVERSAL JOINT CO., INC.
8 Birnie Avenue Springfield, Mass.

As near to you as your telephone

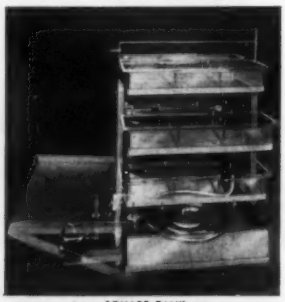
A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Not 9... but 10 LIVES

LONG LIFE IS A FEATURE OF H-D EQUIPMENT

Equally important is its low operating and maintenance cost. But these factors are incidental to the *performance* features that bring lowered manufacturing costs and better made products wherever installed.

For twisting, bunching and stranding operations, H-D equipment assures consistent straight-break strength... stronger, ply for ply... uniformity of twist, free from broken ends — and many other advantages. Bulletins, available on request, explain H-D equipment in detail. Worth reading. Write for copies, outlining your manufacturing problems, TODAY.



SQUARE TANK

HASKELL-DAWES MACHINE CO., INC.
2231 E. ONTARIO ST., PHILADELPHIA 34, PA.

MAIL RETURNS

Nostalgia Evoked

FROM WILFRED BANCROFT, '97:

I have just read with great interest and a touch of nostalgia the "History of Bacteriology at M.I.T." by Murray P. Horwood in the January, 1953, Review: the references to Professor Sedgwick in that article brought up happy stimulating memories. He was a great scientist, great teacher, and a great human being. I was Course II so I never studied under Professor Sedgwick but I had the good fortune to know him and Mrs. Sedgwick and to share the hospitality of their charming home.

In the Class of '97 *Technique*, page 189, is a rather intimate biography of Professor Sedgwick; as he was kind enough to read this before publication, the facts in this brief life are correct.

Haverford, Pa.

Ordeal Omitted

FROM WM. HOWARD BEASLEY:

In your report on John Jewkes in the February, 1953, issue of The Review (page 211) you failed to mention his book *Ordeal By Planning* (Macmillan Company). This book was widely read both in England and in the United States, and had considerable effect in reversing the trend "to the left." It was frequently quoted by Raymond Moley. Jewkes should be heard more!

Dallas, Texas

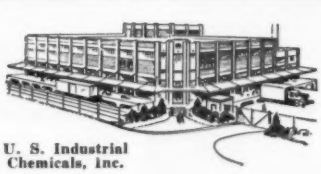
Philosophical Profit

FROM SAMUEL E. MCCRARY:

I wonder if you could send me three copies of the January, 1953, issue of The Review. I am particularly interested in the article "The Two Philosophies" by F. Alexander Magoun and R. Carter Nyman.

I would like to pass this article on to an admiral and to a member of the clergy. I believe they will profit by reading it. The other copy I would like to keep for myself.

Falls Church, Va.



U. S. Industrial Chemicals, Inc.

Need Plant Expansion?

If so, outline your requirements to us and we will give you promptly an estimate of cost and time required to build—information helpful to executives before making commitments for land, machinery, etc.

W. J. BARNEY CORPORATION
Founded 1917
101 Park Avenue, New York
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett, '20, President

BEYOND THE HORIZON....

Designers are seeking new alloys from the metallurgist in order to develop higher speed transportation.

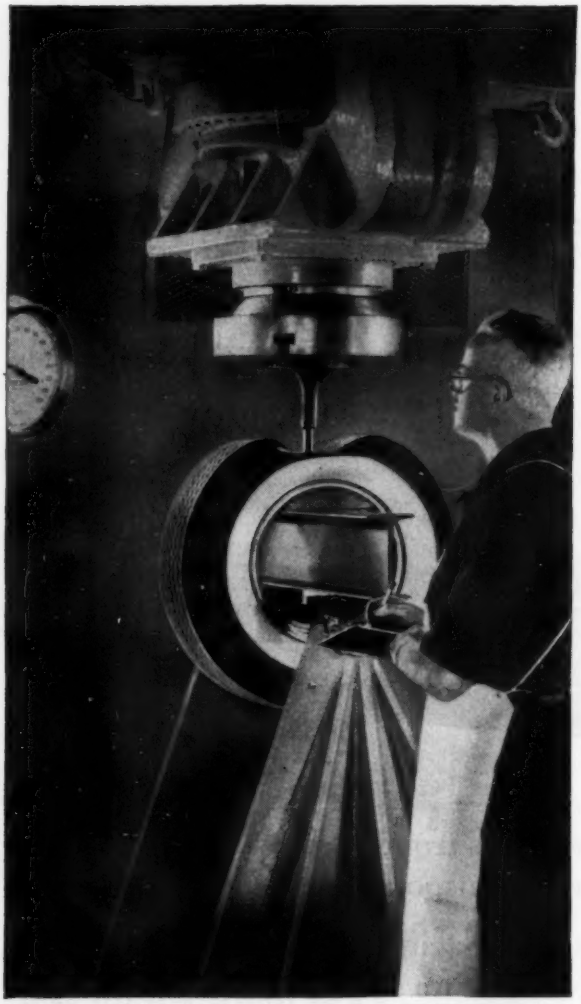
Higher speed calls for materials having greater strength in lighter sections, often with little or no sacrifice in toughness. Molybdenum contributes vital properties to better alloys which will certainly be developed for the future.

Climax furnishes authoritative engineering data on Molybdenum applications.

Climax Molybdenum Company
500 Fifth Avenue · New York City 36 · N.Y.

MOLY

Only a Nylon Cord tire could withstand this pressure...



This test is like driving a blunt spear deep into your tire. The rounded end of that hydraulic punch is only 1¼ inches in diameter! Three types of tires took this test. The standard cord tire failed at 1480 lbs. The second, with regular premium cords, failed at 2500 lbs. But the All-Nylon Cord Double Eagle took 3876 lbs., before that tough Nylon Cord body failed!

Get this extra strength and safety in the All-Nylon Cord Double Eagle!

We call this All-Nylon Cord tire the Plus-10 Double Eagle because it is superior to any other tire in the 10 most important aspects of tire service! Up to 42% greater mileage! Safer, surer traction! And the most luxurious ride on the road. But with all its advancement, the All-Nylon Cord Double Eagle costs only about 5% more than premium tires made of rayon! Goodyear, Akron 16, Ohio.

America needs better, safer roads. Let's bring them up to PAR.

PLUS-10 DOUBLE EAGLE – The world's finest passenger-car tire!

GOODYEAR

Double Eagle, T. M.—The Goodyear Tire & Rubber Company, Akron, Ohio

H. Armstrong Roberts

"With the calm patience of the woods I wait
For leaf and blossom when God gives us Spring!"
—John Greenleaf Whittier

THE TECHNOLOGY REVIEW

TITLE REGISTERED, U. S. PATENT OFFICE

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CONTENTS *for April, 1953*

Vol. 55, No. 6

BATON MAJOR • *Photograph by Harold E. Edgerton* ..... THE COVER
Sequence of views of baton twirling, photographed by use of light source flashing 60 times per second

PYLONS OF INDUSTRY • *Photograph by Lewis T. Reed* .. FRONTISPIECE 304
From a group of photographs exhibited at the M.I.T. Photographic Salon in March, 1952

SOCIAL ASPECTS OF AERONAUTICS ..... BY JEROME C. HUNSAKER 309
Society is in the painful process of adjusting itself to the revolutionizing innovation of flight

SCIENCE AND RELIGION ..... BY H. B. PHILLIPS 314
A mathematician looks at science and morals, and concludes that world morals will steadily improve

AN M.I.T. ENTERPRISE IN OCCUPATIONAL HEALTH
BY HARRIET L. HARDY 315
Research, Occupational medicine, and education are combined to safeguard health in a technological environment

PROJECT GLACIER ..... BY E. H. CAMERON 319
Glacial deposits provide the raw materials by which the New England farmer marked the limits of his property

THE TABULAR VIEW • *Contributors and Contributions* 298

MAIL RETURNS • *Letters from Review Readers* 300

THE TREND OF AFFAIRS • *News of Science and Engineering* 305

THE INSTITUTE GAZETTE • *Relating to the Massachusetts Institute of Technology* 322

Editor: B. DUDLEY

Business Manager: R. T. JOPE

Circulation Manager: D. P. SEVERANCE

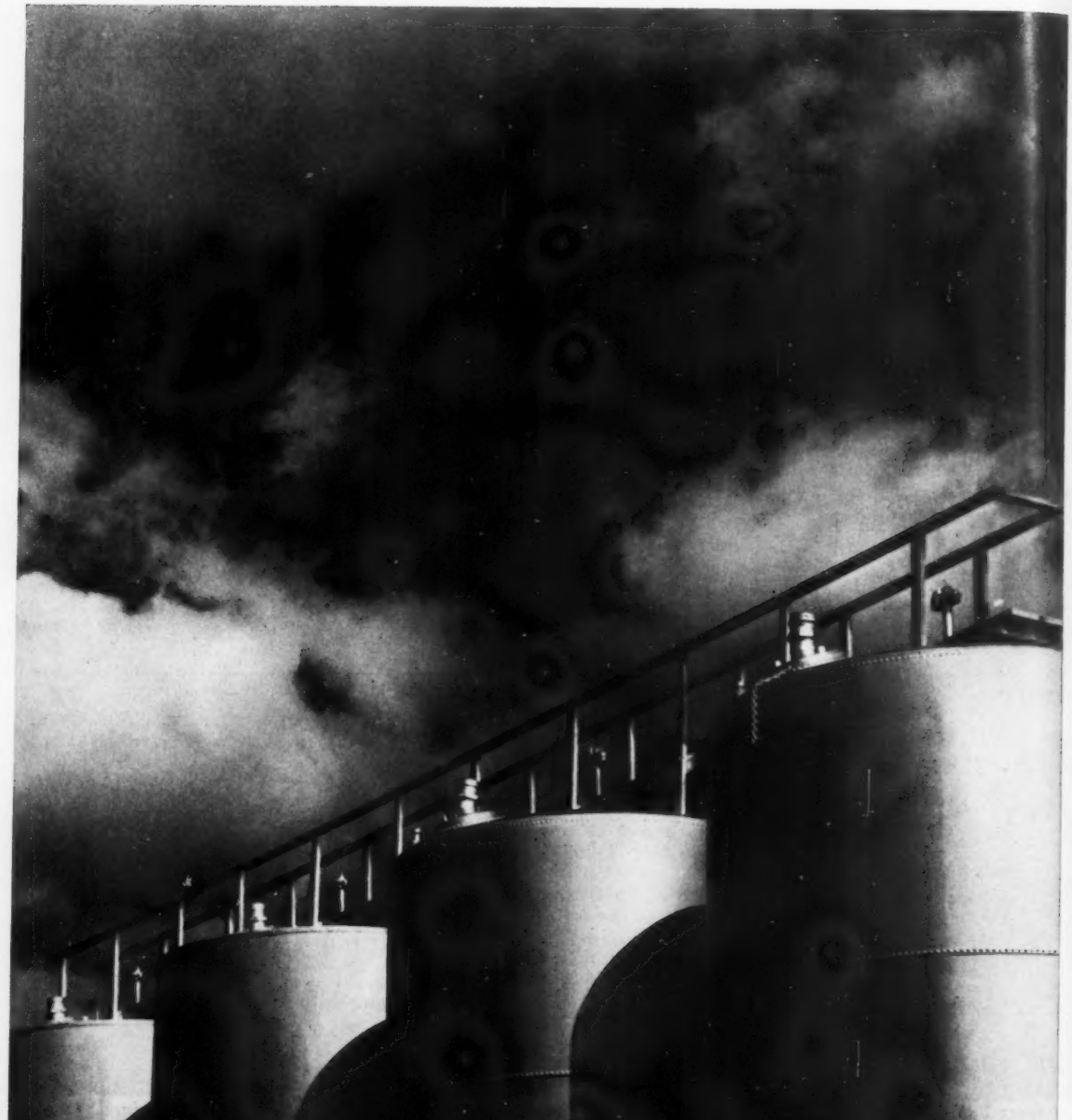
Editorial Associates: PAUL COHEN; J. R. KILLIAN, JR.; WILLY LEY; F. W. NORDSIEK; J. J. ROWLANDS

Editorial Staff: RUTH KING

Business Staff: EILEEN E. KLIMOWICZ; MADELINE R. MCCORMICK

Publisher: H. E. LOBDELL

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Edwin D. Ryer, President; H. E. Lobdell, Executive Vice-president; Hugh S. Ferguson, Dwight C. Arnold, Vice-presidents; Donald P. Severance, Secretary-Treasurer. Published at Hildreth Press, Inc., Bristol, Conn. Editorial Office, Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the Post Office at Bristol, Conn. Copyrighted, 1953, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect change of address, for which both old and new addresses should be given.



Lewis T. Reed, A.R.P.S., A.P.S.A.

Pylons of Industry

THE
TECHNOLOGY
REVIEW

Vol. 55, No. 6 April, 1953

The Trend of Affairs

Radiant Risks

Ever since Roentgen discovered x-rays in 1895, danger of radiation injury to human beings has existed. X-rays, together with alpha, beta, and gamma rays, are designated as "ionizing radiation." All four of these radiation types do their damage by injuring or destroying living cells through ionizing action. The injury may be superficial, such as the "burns" (really ulcers) suffered by the early experimenters with x-rays; or may be more profound, such as damage to the tissues that regenerate the blood. Much remains to be learned of the ramifications of radiation injury, although current research on the subject is extensive.

The advent of nuclear fission and atomic bombs, and publicity on radiation injuries to the people of Nagasaki and Hiroshima, have created general public awareness of radiation injury. It is also generally known that elaborate and effective precautions are taken – indeed are legally mandatory – in the operation of nuclear reactors and particle accelerators, and in the handling and use of radioactive isotopes. What is not so generally recognized is the extent to which total radiation exposure of the general population has grown, not only through the newer radiation sources related to nuclear fission but also from conventional sources, such as x-rays used in the healing arts. A summary* of this subject just published gives considerable pause to the reader.

Growing and widening use of x-ray units may be projected into one's own experience, by considering that ubiquitous practitioner of the healing arts, the dentist. A decade or so ago, few dentists had their own x-ray units; patients were referred occasionally to radiologists who used heavy, elaborately shielded, permanently installed equipment. Today, lightweight portable x-ray units enable any dentist to make roentgenograms in his own office. Indeed some 65,000 x-ray units are now employed by dentists. X-ray equipment used by physicians, osteopaths, and chiropractors, and in hospitals bring to more than 125,000 the total number of x-ray units now used in this country for diagnosis, and for treatment of dermatitis, cancer, and other ills.

In addition to medical uses, x-ray devices are widely used in industry to find defects in castings and welds, to detect foreign material in packaged products, and to scan employees for prevention of pilfering. In some retail shoe stores, x-rays are used to check the fit of shoes. In numerous research laboratories, particle accelerators and high-voltage x-ray equipment are used as research tools. X-ray diffraction is employed for crystallography studies at about 1,500 locations. The electron microscope uses x-rays; some 500 of these instruments currently exist in this country.

Radioactive isotopes produced by the Atomic Energy Commission are effectively controlled and inventoried. It is noteworthy, however, that the naturally radioactive elements, such as radium, may be bought without restriction on the open market. Numerous losses of sizable quantities of radium have occurred. This lost radium is around somewhere, adding significantly to the total radiation exposure in the United States.

Radioactive isotopes are employed in tracer studies in virtually every modern biological laboratory. These isotopes are also widely used in diagnosis, and in the clinical treatment of various conditions, such as hyperthyroidism and cancer. Radioactive elements are used in industrial thickness gauges, in self-luminous paints, and in static eliminators employed in the textile, paper, printing, photographic, and telephone industries, and on laboratory equipment.

Other major sources of radiation include the mining and milling of uranium, and operation of nuclear reactors not only by the Atomic Energy Commission

* Moeller, D. W., Terrill, J. G., and Ingraham, S. C., "Radiation Exposure in the United States," *Public Health Reports*, **68**:57-65 (No. 1, January, 1953).

Raymond E. Hanson

◀ *Contrast of the old and the new is this tower used during the Eighteenth Century when Boston was evacuated by the British. The artillery for this Revolutionary Fort at Roxbury, Mass., was brought from Fort Ticonderoga, New York.*

but also by universities and industry. Over 100 particle accelerators of various types are now in operation in the United States. Finally, substantial radiation results from atomic bombs detonated at Atomic Energy Commission proving grounds for testing purposes.

How much radiation exposure does this all add up to? Is there any threat to human well-being? First it must be acknowledged that mankind always has been exposed to some degree of radiation, from cosmic sources and from natural radioactive elements. It is estimated that an individual who lives to be 70 years of age receives, during his lifetime, an average of nine roentgens of radiation from such sources. (The "roentgen" is the unit of ionizing power, and hence of potential biological balefulness.) This degree of irradiation does no known damage. Indeed the National Committee on Radiation Protection recommends as safe up to about 15 roentgens per year, with the whole body exposed to continuous daily gamma radiation. As a result of the manifold radiation sources summarized, some members of the general population may be exposed to radiation approaching the safe maximum. Clearly the possible public health effects of the cumulative radiation from the many sources now existent in this country – many of them unsuspected – must be watched closely.

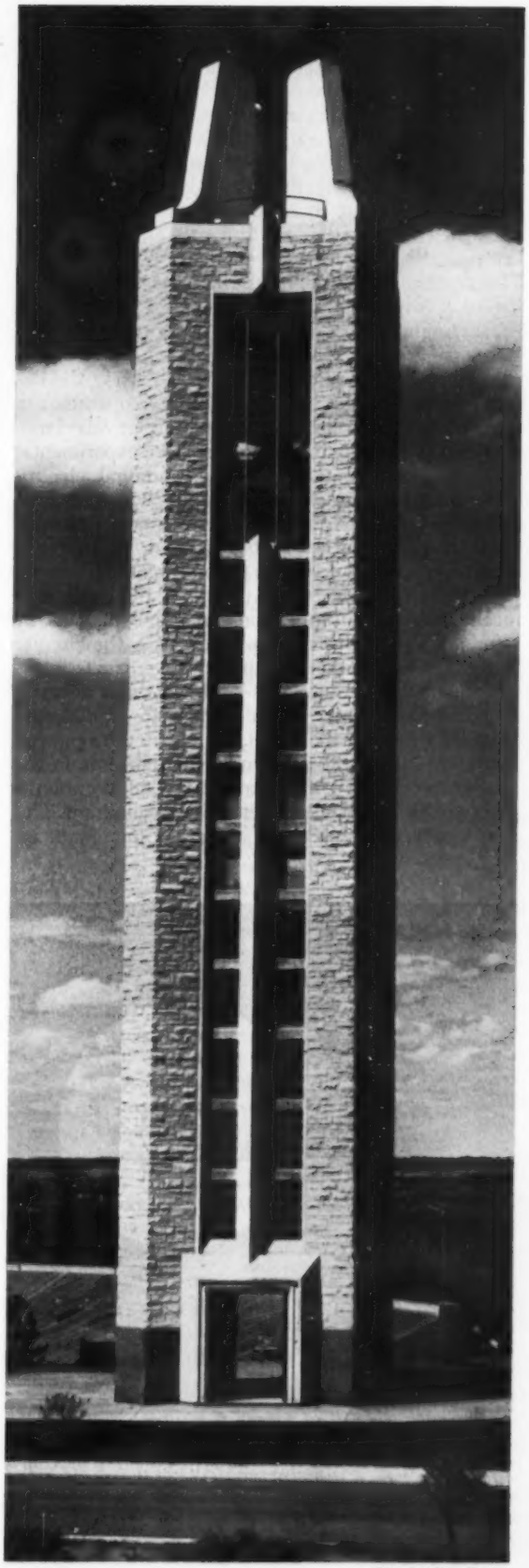
In exposure to ionizing radiations, the need for exercising care is greatest among those persons whose industrial or research activities bring them into contact with radioactive substances or radiation-producing machines. Such persons face a potential occupational hazard against which adequate precautions and protective measures can readily be taken. An unusual program of preventative medical service which meets the challenge of technological occupational hazards has been in operation at M.I.T. since 1947, and is described on page 315 of this issue of The Review.

Demand and Supply

JUST two years ago, the British government started the rationing of sulphur and sulphuric acid. Europe and Great Britain were joining in demands that the United States ease the world sulphur shortage by increasing its exports. American sulphur producers and users were insisting that exports be curtailed. Visible reserves along the Gulf Coast of this country, which supply the bulk of the world demand for this basic chemical raw material, were being exhausted. Today, though demand has not lessened, production has increased sufficiently so that the shortage, if not eliminated permanently, is at least greatly eased. United States consumers may now keep a 60-day supply on hand, instead of only a 25-day supply, and distribution controls on sulphuric acid have been dropped.

Sulphur is not a particularly rare material. It ranks about 15th among the most common elements in the earth's crust, just below carbon and well ahead of

► *A product of Twentieth Century engineering and architectural form is this New War Memorial which has been erected at the University of Kansas in Lawrence. Among the differences in shaft construction of the two centuries, are the apertures.*



Ward Allan Howe

such important industrial metals as copper, zinc, and lead. Many large deposits, such as those in Sicily and Spain, have been worked for centuries. However, when the huge sulphur domes of the American Gulf Coast were discovered, and the invention of the Frasch process permitted the sulphur to be pumped up in almost pure form, the United States obtained a near monopoly of the world market.

Very large deposits of metallic sulphides or pyrites are scattered throughout the world, and Spain, Portugal, and Cyprus export substantial amounts. It takes almost twice as much plant to make sulphuric acid from pyrites as from elemental sulphur, however, and neither the mining nor the chemical industry is geared to replace crude sulphur to a major extent.

An encouraging event is the recent discovery of a large sulphur dome in the lower Mississippi Delta region. Construction of the plant is in progress and production is expected to start in 1953. Planned output is 500,000 tons a year, the equivalent of about half the free world's deficit.

The world's present annual production of native, or crude, sulphur is in the order of 6,500,000 tons, with the United States mining the great bulk of it. Prewar production was less than half this figure. The sulphur equivalent of the very large tonnages of pyrites that are mined yearly is at least several million tons. Significant amounts of sulphur are also produced as by-products from mining, metallurgical, and chemical processes. Many plants already exist for salvaging sulphur from copper smelters, coke-oven operations, petroleum refinery gases, and city gas production. It is estimated that the total amount of sulphur used by the world, from all sources, is over 12,000,000 tons per year.

When the outbreak of the Korean War brought the world's sulphur shortage to the crisis stage, long-range plans for increasing the supply were made that include nearly 100 separate projects. Many new mines have been opened, there has been a revival of interest in deposits hitherto considered too inaccessible to merit exploitation, and new plants for salvaging by-product sulphur have been completed or are under construction. Collectively, these projects are expected to add 4,000,000 tons of sulphur annually to the world's supply in 1955.

Analogue Multiplier Tube

ADVANCES in science and engineering during the past few years have greatly increased the need for high-speed electronic computers. One of the most serious problems confronting the person wishing to build a high-speed analogue computer is that of finding a suitable means of multiplying. Scores of devices and circuits have been used for this operation; however, none of them is entirely satisfactory for general applications. The basic requirements imposed on a multiplier that is to be useful in general applications

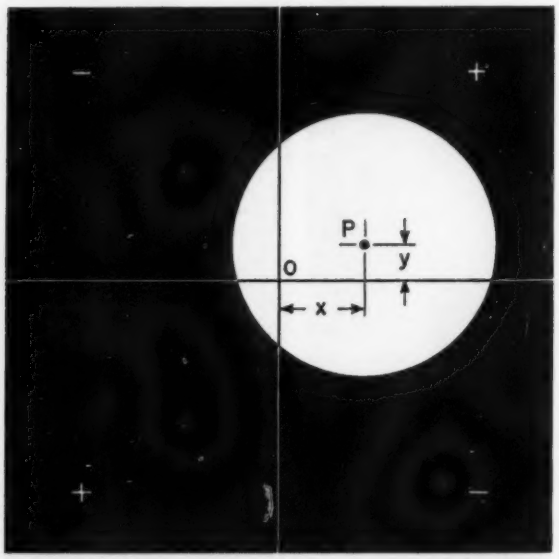
are: (1) good accuracy, (2) fast operation, and (3) four-quadrant operation. The last of these requirements means that the multiplier must accept both positive and negative values of each input variable and must provide the correct algebraic sign with the product. In general, high-speed operation is obtained only by sacrificing accuracy, and several otherwise attractive means of multiplying provide only one – or two – quadrant operation. By introducing a new basic principle the electron-beam multiplier is able to provide fast operation in four quadrants with good accuracy. The analogue multiplier tube has been devised by Ernest J. Angelo, Jr., '49, Assistant Professor of Electrical Engineering, in research sponsored by the Bureau of Naval Ordnance.

High-speed operation is obtained by using the deflection of an electron beam as the basic operation in the multiplier. A circular beam of relatively large diameter (about one inch diameter in an experimental tube) is projected through a conventional electrostatic deflecting system upon a metallic target consisting of four quadrants that are insulated from one another. From the currents collected by the four quadrants an output voltage proportional to the product of the two deflecting voltages is obtained. The mechanism of multiplication can be explained by reference to the illustrations which show the circular beam impinging upon the target. The currents in the four quadrants are designated positive and negative as indicated. With the center of the beam, *P*, deflected from the center of the target, *O*, it is clear from symmetry that the algebraic sum of the currents in the shaded areas, at right, cancel when due attention is given to the sign of the current in each quadrant. This sum is determined by an electrical adding circuit external to the multiplier tubes, and is equal to the current in the central rectangular area unshaded in the right-hand illustration. If the current density is uniform throughout the entire area of the spot, the algebraic sum of the quadrant currents is proportional to the product of the *x* and *y* deflections, so long as the spot is not completely deflected from any of the quadrants.

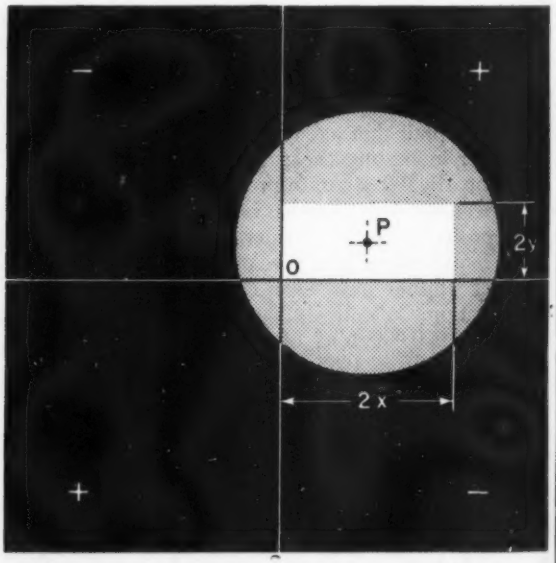
In an experimental tube, the maximum errors were approximately 2 per cent of the maximum product under static operating conditions. The speed of operation was limited by parasitic capacitance shunting the output circuit. For the impedance level selected, the response to a suddenly applied signal was within 2 per cent of its final value within 10 microseconds.

The accuracy of multiplication depends primarily on the uniformity of current distribution in the electron beam, and the magnitude of the output voltage depends on the total current in the beam. Therefore an electron gun of special, although simple, design is used to generate a high-current, uniform beam. The accuracy also depends on the linearity of deflection and the accuracy of the target construction; however, these considerations do not constitute a serious problem. Manufacuring problems should be no more difficult than those encountered in the production of conventional cathode-ray tubes.

In addition to its applicability in electronic computers in general, the tube appears to be well suited to a variety of special operations that involve multiplication. Among these are modulation, demodulation, harmonic analysis, the computation of certain types of integrals, such as Fourier transforms and correlation functions, and, in conjunction with a differentiating circuit, general integration.



The mechanism of multiplication by an electron tube may be illustrated by means of this diagram. An enlarged spot of a cathode ray tube is deflected over four conducting quadrant plates insulated from each other. The displacement of the center spot, P, from the intersection of the quadrants, O, is made proportional to the displacements, x and y, whose product is desired.



With proper attention to quadrant signs, cancellation of currents occurs for those regions of the enlarged spot represented by the shaded areas. Uncompensated current, represented by the unshaded area, whose dimensions are indicated as 2x and 2y, is proportional to both the horizontal and vertical deflections of the spot, and hence is a measure of xy, or the product of x and y.

Ewing Galloway, N.Y.

Social Aspects of Aeronautics

Society Is in the Process of Adjusting Itself to the Innovation of Flight. The Process Is Painful and the Ultimate Pattern Has Not Yet Been Evolved

By JEROME C. HUNSAKER

For Americans, it may be pleasant to think that the Wright brothers invented the airplane in a flash of genius and so realized the age-old dream of human flight, but this would be to capture only a portion of the truth. However, the Wrights were the first men to fly, and they did devise and use a practical means for controlling their airplane in pitch, roll, and yaw. Had they not succeeded, it now seems certain that someone else would. The time was ripe, the incentive great, and the basic concepts of the airplane and its propulsion existed. Mechanics was highly developed at that time and ready for engineering application.

The airplane was born into a society able and ready to lavish all the resources of the machine age on the mechanical infant. The airplane was also born into a time of abundant energy from oil, and at a time of violent nationalism. Great States were changing in relative power and were strained by economic pressures and instability. The Twentieth Century opened with the Russo-Japanese War and soon experienced World War I.

It is no wonder that the airplane was at once taken up for intensive development by those States that foresaw its military possibilities. In the succeeding years we have witnessed the progressive conquest of the air. While the airplane's rapid development into a practical vehicle was a consequence of the state of the society into which it was born, it soon began to change that society. Every person alive today is affected. There is a change in his relation to distant places and peoples. Traditional geographical barriers have disappeared and the air presents a clear route to those distant places and peoples; a route for trade and the interchange of visits and ideas.

Likewise, the air can be a route for the arrival of sudden destruction. Air power reaches into the interior of a country, to islands formerly isolated by the sea, and gives a new and frightening weapon to an aggressor. Just now, the divided world is in a state of strain and many wish there were no airplanes with bombs to destroy the illusion of isolation. The times are no doubt dangerous, but that is not a new condition. Man has always feared a fiery end. The threat should impel nations to prudence and common sense, just as the Last Judgment of religion is an incentive to individual virtue.

There may be an historical parallel with ships. In the Mediterranean, sea power served trade and colonization and likewise war. The sea power of Elizabethan England led to an immense expansion of overseas enterprises. The golden age of Elizabeth and Shakespeare came to full flower with the opening of the sea as a universal highway.

The airplane is relatively new, but air power has already profoundly affected the outcome of a great war and still constitutes a threat to the security of great nations. In its civil applications, however, the airplane has yet to attain its potential world-wide utilization. But air transportation is already well established and is growing as fast as political, economic, and technical conditions permit.

A. Devaney, Inc., N.Y.

Since Charles Lindbergh's famed Atlantic flight, approximately 1,500,000 ticket-holding passengers have flown across the Atlantic Ocean by scheduled air line service, according to the International Air Transport Association. Probably an equal number have crossed on military and nonscheduled air transport. This summer, it is expected that more than 1,000 passengers will fly across the North Atlantic every day.

The airplane of today has come a long way from the Wright airplane of 49 years ago. The basic type has continued to the present day but its performance was rapidly improved by application of the advancing technology of the new century. Orville Wright was not unaware of the military value of the airplane, since his first sale in 1908 was to the U.S. War Department. However, he always contended that he and his brother Wilbur thought of their airplane as a contribution to international communications, trade, and good will. The next 50 years may prove him right.

Designers were at first the inventors, then engineers and scientists took over. The demands of the airplane led to the creation of strong light alloys, high-octane gasoline, and high-output engines, and special operating equipment using radio, radar, and autopilots. Old ideas for a gas turbine were resurrected and applied with spectacular success to jet propulsion.

Taking speed records of propeller-driven airplanes as a measure of progress, the increase has been from about 40 to nearly 500 miles per hour, or at a rate of some 10 miles per year of effort. Simply projecting this trend suggests that the next 50 years should bring the speed record to 1,000 miles per hour. A fallacy must be present here, because the newspapers inform us that jet-propelled research airplanes have repeatedly flown at supersonic speeds. Closer examination of the position shows that the jet-propelled airplane is not the airplane of the Wright brothers; something new and revolutionary has been added. A radically lighter and more powerful means of propulsion, eliminating the propeller, is a mutation that upsets the trend of statistics of past growth. The propeller-driven airplane has indeed made a normal growth curve, topping off between 1940 and 1950, with a maximum sea-level speed below 500 miles per hour. The performance of jet-propelled airplanes is too recent to establish a trend from which to venture a forecast. All we know is that we shall have to do with a new kind of airplane to which vastly increased thrust can be applied.

The trends of technical progress are usually evident from a comparison of current designs with research data not yet applied, but there is always a time lag before research findings come into general use. For example, it is evident that the jet propulsion gas turbine is revolutionary in its effect of affording more power to modern airplanes. The reciprocating engine is mature and efforts to improve it have reached a stage of diminishing returns. The gas turbine is simpler, lighter, and more compact. Its big disadvantage is its youth, and consequent occasional unreliability and a tendency to extravagance. Youth will be outgrown, and hence one predicts that reliability and economy will be established.

Air transport cannot proceed at once to exploit many possibilities of the art suggested by current research. A number of difficult problems must first find practical solutions. The public is conditioned to expect uninterrupted progress but the trees do not grow to the sky. There are always limitations in any art; either permanent, due to physical laws, or temporary, due to the current state of technology.

Consideration of the power needed for very high speed shows that there is a physical limitation to the speed of the conventional airplane due to the compressibility of the air. Near the speed of sound, the air offers very greatly increased resistance. It fails to move aside as the airplane advances. Shock or compression waves are formed which may destroy the smooth flow over the wings, changing the aerodynamic forces in magnitude and distribution. As a result, the airplane may become unbalanced, get out of control, or it may disintegrate under severe buffeting. One can say, from what is known now, that conventional airplanes with piston engines are limited, for practical use, to speeds well below the speed of sound. The piston engine has not enough power to push to such a speed, and the conventional airplane could not be flown there even if enough power were applied.

Actually, there is no absolute sonic barrier. Jet propulsion can give power enough, and modern aerodynamic research has shown how to shape wings and bodies to be flown safely through the sonic range of speeds and into the supersonic. Here we have an answer to the question as to the relative precedence of research and bold experiment. Bold experimenters might have tried for supersonic flight as soon as jet propulsion was available, but they would not have survived enough experiments to learn from their experience. Without the guidance of aerodynamic research, supersonic flight would not have been achieved experimentally today. The writer believes

that there is good reason to expect that technological progress based on applied mechanics will continue to improve the airplane for use in either peace or war.

A brief review of the development of air transportation in the United States may serve to bring out some of the social and economic effects of this innovation.

Air Transportation

Civil air transportation began in the United States in 1926 with postal contracts to pioneer air lines. The air mail payment became in fact a subsidy to encourage the development of civil aeronautics. Whether it was a subsidy to the operator, to the user of the air mail, or to the passenger is immaterial. The effect was to promote a rapid growth, sometimes too rapid, of air transportation. The airlines carried some 500,000 passengers in 1934 but were losing money. There was cutthroat competition in bidding for air mail contracts and passengers. Losses in this business were chronic.

The Civil Aeronautics Act of 1938, which evolved after prolonged discussion, furnished a practical means of reviving and encouraging the air lines. The Act authorized, when in the public interest, financial aid to private air lines that met safety and economic standards. Mail payments and federal airways constituted the lever to develop a private air transport system to be adequate for the postal service, the air commerce of the nation, and the national defense. The Civil Aeronautics Act is a social document of great significance, as it states continuing social objectives and establishes means to implement its purposes.

In the United States, air transportation is already "big business," employing more than 1,300 airplanes, and nearly 90,000 people and carrying 20,000,000 passengers in 1951. Aircraft manufacturing is third in place among U.S. industries, exceeded only by steel and automobiles. Passenger revenue for the domestic air lines exceeds the total for Pullman travel, the railroad's first-class service. However, Pullman travel remains about the same, and one must conclude that air transportation largely represents the tapping of a new field of patronage.

Safety

Now as to safety. The air line record on its face looks pretty good. In 1930 there were 23 fatalities for every 100 million passenger-miles flown by U.S. domestic air lines. By 1950, this rate had been chopped to 1.2 and seems to stabilize around that figure. The risk is evidently satisfactory to the insurance companies who offer passengers a $5,000 policy for $0.25. To some degree, safety and maintenance of schedules are opposed. To improve schedule keeping, flights are made in bad weather. Faster airplanes will require more elaborate ground facilities, and more precise traffic control if the safety record is to be maintained.

Of all the aids to safe operations under bad weather conditions, the instrument-landing system (I.L.S.) probably has contributed the most. Progress has also been made in the technique of air-traffic control. In 1947, the capacity of a normal airport permitted seven aircraft to land and seven to depart in an hour when visibility was low. Today, under the same conditions, the potential capacity has been increased to 32 arrivals and departures. New and more trustworthy static-free electronic devices should help to smooth out the bad weather congestion at busy airports, but very fast jet-propelled transports are projected which promise to complicate the situation. These high-flying craft cannot be held stacked up in the present manner over an airport, waiting their turn to land. Their fuel supply is quickly used up. Some system of dispatching must co-ordinate departure and arrival times to give a clear right of way.

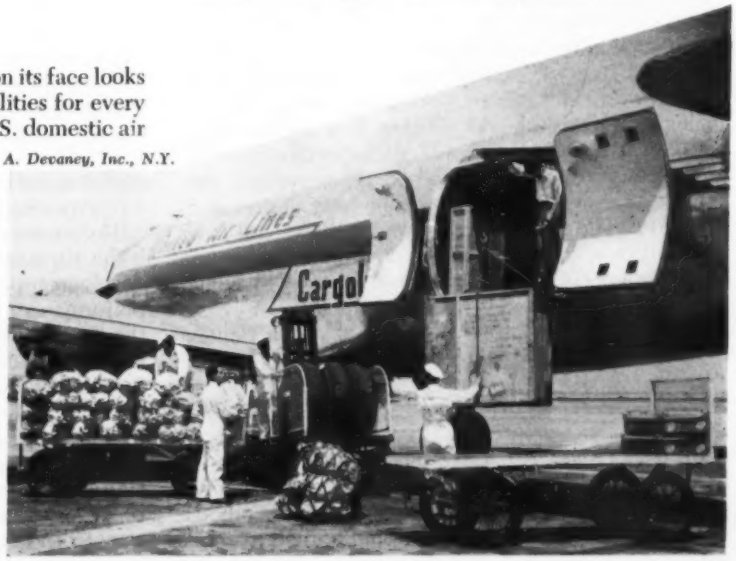
Perhaps it will prove to be both unsafe and impractical to handle all types of air traffic at the same airport. A great city may well have several airports, each organized to handle one kind of traffic.

Airports

It has been reported that more than half of all airplane accidents are associated with take-off and landing operations. This may mean that these operations are too difficult or that our airports need improvement.

One ought to marvel that a normal young man can be hired to launch a 50-ton machine into the air as a routine task, to speed it up to 300 miles an hour, to find his specified destination, and then to bring it down gently to rest. The young man is no genius, but he knows what to do to control a complex apparatus that has evolved from the applied mechanics of the last half century. The work of inventors and engineers is never done, and continually requires that the task of the pilot be made simpler and more straightforward. Airplane, airport, and intercommunications must be adjusted to accomplish the critical function for which they exist, in an art notorious for change.

The growth of air transportation has put a severe strain on many major airports. Original facilities have become outgrown and many airports are approaching saturation. Larger and faster airplanes, making more



A. Devaney, Inc., N.Y.

Robert Weichert from A. Devaney, Inc., N.Y.

landings and take-offs in worse weather, will call for longer runways, larger clear-approach areas and a check to community encroachment.

Frequently, the airport has acted as a magnet to attract a surrounding industrial and residential settlement which now is subjected to noise and hazard. A desirable pattern of city growth can be prevented by a busy airport unless it be incorporated into regional and city development plans with the expectation of a useful life, taking into account planned possibilities of expansion, comparable to that of railway terminals.

Can future airplanes be designed to conform to airport limitations and still take full advantage of improvements made possible by technical progress? Research airplanes have recently flown at supersonic speeds at high altitude. They could not have operated from existing airports. It may be many years before the results of such research are applied in air transportation, but future clever designers will try it.

The writer ventures to suggest a parallel with the much older problem of the naval architect. He designs ships which must enter certain harbors and pass through certain canals. Tankers for Persian Gulf oil conform to Suez Canal restrictions on draft.

In the course of time vessels have come to be designed for geography. The great Atlantic liners can enter only a few great ports. World-ranging tramp steamers are designed to enter almost any port. Under the combined influence of geographic and economic considerations and technical possibilities, a merchant marine has evolved consisting of various kinds and sizes of vessels, with corresponding port facilities. Probably air transportation, influenced by analogous factors, should develop in a similar way, with airplanes designed for the specific airports served, and airports designed to accommodate the kind of air transportation the community desires and can afford. The evolution of ground facilities will now lead and then lag behind the requirements of the airplane designer. Change in the basic scheme will come in response to pressures, not continuously, but at infrequent intervals, just as vessels and port facilities have been adjusted to each other over the last century.

Human Factors

In considering safety and accidents, I must not leave human factors out of account. Medical and physiological science have been intensively applied to methods of selection and training of pilots and to their maintenance in good condition. However, there is an inescapable reliance on human judgment and skill. A large proportion of the accidents in recent years could have been prevented by better flying qualities, more reliable engines, better weather forecasting, better lighted runways, or some other improvement in whatever it was that made flight conditions so difficult that the pilot made a mistake. If a task increases in difficulty, errors grow more frequent.

The process of assisting the human pilot by an automatic control system started about 1915 when Lawrence Sperry first demonstrated the gyroscopic pilot of his father, Elmer A. Sperry. This process continues and has reached the stage where autopilots are standard equipment on practically all large airplanes, civil or military. The autopilot replaces the human pilot for routine steering on course and for maintenance of the attitude of the airplane. A recent development combines the autopilot with radio reception devices so that an airplane can be automatically guided along a proper approach path and landed on the runway, in accordance with the airport's radio signals.

Helicopters

The place of the helicopter in air transportation is not yet clear, but its advantage of starting from the backyard, rather than from a distant airport, is impressive. Since the helicopter is just now having intensive development because of its military advantages, we may feel hopeful that most of its handicaps will be removed. These handicaps are not fundamental. The future helicopter could have a pay load equal to that of an airplane designed for the same speed. It is fairly safe to predict that before long we shall see helicopters shuttling between airports and downtown terminals with "bus loads" of passengers.

The obvious vehicle for efficient air transportation is the airplane which, even after 50 years of intensive developments, is ripe for substantial improvements in performance, economy, and safety. The airplane of the Wright brothers has evolved into the modern air transport under the stimulus of practically unlimited funds in two wars and the devotion of the best scientific brains of the age. A new kind of professional man has been added to those who minister to the needs of society, the aeronautical engineer. This engineer designs and builds airplanes to be useful servants in war or peace, plans and operates air transportation systems to serve the public and, in general, focuses in his

professional efforts the results of the advancing technology of his time.

I have spoken of the Air Commerce Act as a social document because it implements a national policy to mold the social impact of a branch of technology. This Act governs civil aeronautics and especially air transportation. Other United States statutes make the application of aeronautics to national defense the function of the Defense Department, and make the State, as represented by the President, undertake responsibility for aeronautical research, to insure that both civil and military aeronautics shall be superior in quality.

The Act establishing the National Advisory Committee for Aeronautics provided a unique example of research in a field of applied science undertaken by the State because of its paramount interest. But the example is no longer unique, since the Congress more recently charged the Atomic Energy Commission with responsibility for research in another field of applied science.

The concern of the State with progress in aeronautics is understandable from the primitive obligation of self-defense, and the public interest certainly justifies the advancement of civil aeronautics which offers the hope of a better world order.

Effects of Air Transportation

It is trite but true to say that air transportation has shrunk the world. Distances are beginning to be thought of in hours rather than in miles. One can fly a third of the way around the world in 30 hours.

Concurrent with the growth of air line operations we have recently seen a mushrooming of miscellaneous aviation enterprises: crop dusting, spraying, power- and pipe-line patrols, surveys, forest-fire fighting and, in general, carrying people and supplies by air on urgent missions. A dramatic example was "Operation Locust" in Iran. A call for help to check a plague of locusts was met by a flight of three transports from the United States to Iran, carrying eight small airplanes with spray equipment, nine pilots, six mechanics, and thirteen tons of a special insecticide.

Air cargo in the United States has quadrupled since 1946 but does not yet handle the movement of heavy goods. It does, however, take almost anything that can be got through an airplane's door for which time in transit is valuable. Air cargo has created enterprises where none existed before. It has made possible the shipment of perishable cargo served by no other form of transport. Daily, a great variety of products and commodities are speeded to destinations around the world – pharmaceuticals, clothing, textiles, food and livestock, radios, films, newspapers and magazines, machine parts, even automobiles.

There has also been a mingling of people due to ease of transportation and communication. People are mobile and become migratory in times of economic dislocation. With the international mobility afforded by air transportation, frontiers of nationality should be less of a barrier.

Short-haul air transportation has yet to be developed, but it conceivably could extend the daily commuting distance well beyond 50 miles. While more than half of the U.S. population is now urban, the next generation should see this figure reduced. There are already signs of serious decay in the central residence areas of large cities like Boston and Cleveland.

The influence of air transportation on business extends beyond the convenience of buyers and sellers. It facilitates the central management of widely scattered enterprises. There is already a trend away from giant industrial centers. This should favor the growth of the smaller towns.

Air transportation, as competitive private enterprise, is developing under the pressure of technological progress, stimulated by the State and yet regulated by the State. There are two groups of planners in the United States – the managers of the air lines, and the Civil Aeronautics Board in Washington. Both realize that the public wants to go faster, that there is a relation between speed and safety, and that the air transportation system is now vital to the nation's commerce and security.

Planners are always in trouble from past mistakes and future uncertainties. No major industry has ever progressed so rapidly as air transportation nor expanded so fast. But the industry has not reached maturity and must find its way through a maze of economic and technical difficulties. It must make correct decisions about changes it cannot now afford, and about a future only dimly foreseen.

The Airspace and National Sovereignty

The development of world-wide air transportation creates legal problems without precedent in international law. The legal concept of sovereignty above the surface of the earth is older than human flight. The Romans kept open by law the airspace above public highways and sacred ground.

The foundation of present international air law is the Paris Convention of 1919, part of the Versailles Treaty, which stated that "the High Contracting Parties recognize that every power has complete

(Continued on page 338)

U.S. Air Force

Science and Religion

The Association of Good Morals and Progress Assures That World Morals Will Steadily Improve

By H. B. PHILLIPS

To motivate human conduct it is necessary to make assumptions concerning the universe as a whole for which it is not now possible, and may never be possible, to give completely logical support. These assumptions, or beliefs, constitute a form of religion.

Since the time of Descartes, for example, most scientists have believed that nature is subject to invariable physical laws and that these laws are never suspended. One might think this proved by experience. But the mere fact that exceptions have not been observed does not prove that none will be. Many happenings, now a part of everyday life, never occurred before the writer was born. Thus belief in the invariance of physical laws is not so much a result of experience as a first principle in a scientist's religion.

The importance of this principle cannot be overemphasized. There is little reason to think that human abilities have changed appreciably for thousands of years. Yet during each generation, now, the advance made in man's control over nature is comparable to that made during all preceding history. An important reason for this is quite clear. When natural phenomena were thought to express merely the emotional states of various gods, there was little impetus to seek a rational explanation. Under such conditions even geniuses were inhibited from noting correlations that would now be obvious to a schoolboy But belief in the invariance of physical laws is only a static part of a scientist's religion. To this, during the last few centuries, has been added a dynamic phase, mainly a belief in the perpetual advance of the highest forms of life. Conditions on earth may ultimately become such that organic life cannot continue, but that time is certainly millions, perhaps billions, of years in the future. To man, whose significant history extends backward only a few thousand years, a million years may be considered to be effectively infinite. During that time it may be reasonably assumed that the evolutionary advance, which has now continued for more than a billion years, will not be interrupted. This does not mean that the advance will necessarily be continuous. There may be alternate advance and recession, but the average gain during the forward movements will more than compensate the loss during the recessions.

This process has now reached a critical stage. Through increasing knowledge, man is becoming able to influence the process consciously. Good and evil have thus been introduced into the world. Good is that which accelerates progress; evil is that which retards progress.*

This definition of good requires the ordinary benevolent acts of conventional morality since the performance of such acts promotes progress. It is also valid when the conventional rules fail. Consider, for example, a backward community where people are all good neighbors and there is practically no crime, but because of unsanitary living conditions and primitive technology the people have poor health, work very hard, and on the average die at about 30 years of age. Compare this with a modern city where every form of crime is a daily occurrence, but because of more modern medical service and improved methods of doing work the people have excellent health, short hours of labor, and on the average live happily to the age of 70. To the person who dies, the principal difference between death from disease and a knife thrust is that the knife thrust is usually less painful. To call the morals of the primitive community superior to those of the city is then to make virtues of suffering, severe labor, and early death. The purpose of good morals is to reduce these things. Any worthwhile system of morals must therefore provide progress, and if the rate of progress is greatest, the other desirable features will automatically be included.

This association of good morals and progress ensures that world morals will steadily improve. That such has been true in the past is obvious from even a slight inspection of history. For example, Marcus Aurelius is usually considered one of the best Roman emperors. Yet Marcus persecuted the Christians about as much as Hitler did the Jews. The best Roman emperor was thus only about as good as the worst public leader of our times. That this improvement should continue follows, since those who lead in morals do most for progress, and each advance in progress increases the power of those who make the advance. Thus right makes might and so automatically prevails.

This principle is, however, subject to one limitation. The consequences of human conduct are often only statistically determined. In such cases the statement should be, right nearly always makes might. Since the time of Job, religious leaders have been puzzled by the fact that some individuals of the highest

(*Continued on page 334*)

* H. B. Phillips, "On The Nature of Progress," *American Scientist*, 33:256 (October, 1945).

Lecomte du Noüy, *Human Destiny*, page 133 (New York, Longmans, Green and Company, 1947).

AN M.I.T. ENTERPRISE IN Occupational Health

Research, Occupational Medical, and Educational Services Are Combined to Safeguard the Health of Persons Working in a Technological Environment

By HARRIET L. HARDY

SURELY there can be no greater satisfaction in life than to feel that one's work fills a real need. Those of us serving in the Occupational Medical Service of the M.I.T. Medical Department have this agreeable reaction to our work. As far as is known, neither in this country nor abroad, has any other educational institution a technically skilled staff as part of its medical group and specifically charged with devoting its energies to the prevention of: (1) harmful occupational stress in general, and (2) specific occupational disease arising from exposure to dangerous dusts, toxic chemicals, and excess ionizing radiation.

There are very good reasons why a technical institution of higher learning should take a leading part in creating and promoting programs intended to foster worker health, and minimize – if it cannot eliminate – those occupational hazards resulting from progress in technology. Of course it is good policy to establish and maintain attractive and healthful working conditions, and obviously humanitarian aspects become major considerations in any such program. But considerations of humanitarianism and good business practices appeal as strongly to administrators of industrial plants and research organizations as to presidents and deans of colleges and universities. What gives institutions of higher learning their unusual opportunity, as well as their responsibility, to play a pioneering role in occupational medical service is their unique combination of intimate contact with potential technological hazards at the forefront of knowledge in the physical sciences, coupled with an alert medical program in an educational environment.

All three services – research, occupational medical, and educational – are legs of the tripod supporting the health of the populace in a technological society. Without research, the hazards of technological occupations can hardly be studied intimately from first-hand experience. Adequate medical service with means for preventing and minimizing occupational hazards (or correcting their effects, if necessary) will promote the health of individuals with due regard to all pertinent aspects of hygiene. Without the proper educational environment, the lessons of past experience cannot be effectively utilized, especially among students who will later assume responsible positions in industry. Finally, all three of these essential services must be properly integrated if tragedies are to be avoided, such as those in the 1930's when radium poisoning afflicted women painting clock dials.

In 1946, the activities of the Medical Department of M.I.T. were expanded to meet the Institute's needs for its growing personnel and intensified research programs. The Institute's wartime experience (including research for the Chemical Warfare Service, and medical and industrial uses of radioactive materials) gave clear indication that occupational hazards due to harmful dusts, toxic fumes, and radiation could be expected to assume increasing industrial importance. Accordingly, in 1947, the Institute acquired the full-time services of a physicist and the consultation aid of a physician to safeguard the health of students, Faculty members, and research teams working with radioactive materials.

Special hazards in research work at M.I.T. called for additional medical and engineering assistance in 1947–1948. By the spring of 1949, the work in this field had become of such importance that a program on the preventative aspects of occupational medicine was developed with an assistant director of the Medical Department in charge.

All M.I.T. Photos

Dr. Harriet L. Hardy, Assistant Medical Director in charge of the Occupational Medical Service, and Dr. Martin Lubin, '48, a physician of the Medical Department, study the chest x-ray film of a worker once exposed to harmful dust.

Dr. John W. Chamberlain, '28, Associate Medical Director and Surgeon, and Miss Alice M. Browne examine the chemical burn on the hand of a research worker.

At the present time the M.I.T. Occupational Medical Service employs: one full-time physician as Assistant Medical Director in charge of this service; one part-time physician trained in biophysics; one part-time physician trained in toxicology; one full-time physicist as Radiological Safety Officer; one full-time industrial hygiene engineer; and one full-time industrial hygiene chemist. In addition, important supporting services are supplied by an electronics engineer, and assistant radiological officer, four assistants in routine radiation protection, two part-time undergraduate students who conduct laboratory and library activities, and an executive secretary, who keeps this group running well by exercise of tact and knowledge of the many departments and laboratories making up the intricate network of M.I.T. educational and research activities.

That the Institute is able to keep this group actively at work on interesting problems may be easily inferred when one considers the size and scope of M.I.T. interests. Institute personnel totals about 10,000, of whom about half are students, with roughly 1,000 in the Graduate School and in each of the four undergraduate classes. The remaining group of 5,000 individuals is comprised of members of the Institute's Administration, Faculty, research groups in the Division of Industrial Coöperation, and secretarial, library, service, and maintenance personnel. Not counting facilities devoted to undergraduate instruction, there are more than 60 specialized laboratories in which research is conducted in some 40 buildings on the Institute's 60-acre campus in Cambridge. At present there are 11 particle accelerators in operation, in addition to 25 x-ray diffraction units – all producing radiation of one kind or another. In addition, 39 laboratories used radioisotopes in their research during 1952. Constant vigilance on the part of the Occupational Medical Service, however, assures that such facilities are operated with safety to personnel.

One of the striking features of the Occupational Medical Service – especially from an administrative point of view – is that it is part of the Medical Department. Several valuable advantages come from administering the Occupational Medical Service as part of the Medical Department. In the first place, all the assets of the M.I.T. Medical Department become available to the working individual; the surgeon is available for care of burns of the student who may have an accidental laboratory spill, or the dermatologist can give treatment for the chemically caused rash of the research worker subject to unusual toxic exposures. Moreover, by mutual exchange of knowledge, the Occupational Medical Service and the Medical Department develop proper medical examinations involving chest x-rays or blood counts as needed for potentially hazardous work, or may give specialized information to the ophthalmologist in such an episode as the exposure of the eyes to certain levels of radiation. Because it is part of the Medical Department, the recommendations of Occupational Medical Service – such as changes in ventilation equipment or operating procedures – are made purely on a health basis. The Occupational Medical Service has not, and does not want, coercive powers in enforcing recommended changes in work practice at M.I.T. Recommendations, with the detailed reasons for the suggestions, are made to the individual or group concerned by the man in charge. If the problem involves dangerous exposure or great change in current procedure and equipment, the Occupational Medical Service may work out corrective measures with Dr. Dana L. Farnsworth, the Institute Medical Director, and members of the Administration, if necessary, after consultation with the Institute staff involved.

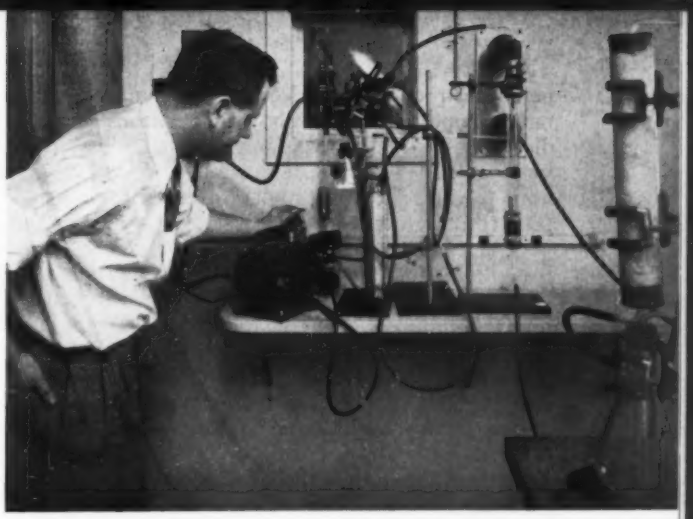
Before describing in some detail the day-by-day work of the Occupational Medical Service, it may be worth while to indicate the location of this Service among the M.I.T. buildings, and to outline the equipment which is available. The four main offices, together with the industrial hygiene laboratory and the counting room, are on the second floor of the Homberg Infirmary. The Infirmary has excellent medical facilities and is centrally located with respect to Institute buildings. Because of their physical proximity, the relationship between the Occupational Medical Service and the Medical Department is direct and simple. Wards previously used could be made available because of the remarkable decrease which has taken place in the last few years at M.I.T. (as in most institutions) in the time sick students spend in bed. There are two doctors' offices, a main office for reception, the library and files, and a large office for the desks of the industrial hygiene engineer and physicist with adjoining storage space for equipment. In the latter office is a microfilm library pertinent to the field of industrial toxicology. This is supplemented by current periodicals. The largest room is the industrial hygiene laboratory with conventional hood, benches, and an adjoining glassed-in office for the chemist.

In addition, an airtight fume chamber has been built into the laboratory for instrument calibration and special studies involving toxic materials. Its total capacity is 10 cubic meters, and it is equipped with an exhaust fan and water with drainage, so that the chamber can be easily cleaned. The industrial hygiene laboratory is adequately provided with equipment especially designed for the measurement of toxic materials in air. Of especial interest are a portable mercury vapor detector, a meter for determining the

amount of halogenated gases and vapors in air, a combustible gas indicator, and direct-reading instruments for such toxic materials as hydrogen sulfide, carbon monoxide and benzene. When laboratory analysis is necessary, because of the nature of the toxic material involved, various types of air-sampling equipment are available, such as filters, electrostatic precipitators, absorbers, bubblers and, of course, pumps and various air-metering devices. Finally, on this floor there is an air-conditioned room where equipment for radiation counting is used. The equipment consists of end-window Geiger-Müller counter apparatus and proportional counters.

Because the work with high-energy equipment is located at some distance from the Infirmary, the Radiological Safety Office is in a separate building. In this office are the headquarters of those members of the group who develop film badges used as protective devices, calibrate instruments for measuring radiation, and keep records of radiation levels throughout the Institute. The Institute has built a cement igloo (10′ x 10′ x 10′ with walls of poured concrete six inches thick, explosion-proof lights and an air-driven ventilation duct) equipped with facilities for handling and storing radioactive wastes for ultimate sea disposal.

Always, but especially in the current research activity of the lively, curious membership of the M.I.T. staff, several skills are essential to provide correct advice on the prevention of hazardous exposures. Knowledge of the literature, skill in the use of measuring techniques, and experience with personal and engineering protective devices, which may be used in the daily life of the Institute, are among the skills made available to Technology personnel. The range of services rendered by Occupational Medical Service extends from work to insure safe handling of the potentially dangerous H_2S in freshman chemistry classes to acquired knowledge of the biological behavior of germanium compounds which have recently become so important in electronic research.



Engaged in aerosol-collection studies is Frederick J. Viles, Jr., '38, industrial hygiene engineer, shown here observing experiment in the dust chamber of Occupational Medical Service.

The unusual and routine activities may be illustrated by a few concrete examples of the nature of the Occupational Medical Service work. The industrial hygiene chemist makes trips to various parts of the Institute to investigate reports of use of toxic chemicals or harmful dusts, and the atmosphere in which the individual is working and breathing may be measured directly. The following materials are most frequently measured: mercury, carbon monoxide, benzene, carbon disulfide, beryllium, chlorinated hydrocarbons and, on occasion, oxides of nitrogen, ether and lead. Certain solvents used as paint removers, or typewriter or metal cleaners, may be analyzed for toxic components. The chemist may have to spend considerable time developing methods of analysis for toxic materials not previously encountered, and is often called upon to do original work on various phases of the problems of collecting and sampling of such materials. Alone, or after consultation with the literature and the rest of the staff of the Occupational Medical Service, the chemist may try to persuade a worker or a group to substitute a safe material for a harmful one. For example, the use of the relatively innocuous trichlorethylene may be urged in place of the dangerous carbon tetrachloride in cleaning operations.

After the chemist has measured the air levels of toxic materials in a given operation, the industrial hygiene engineer will bring his skills to the problem of altering the procedure or developing ventilation that will protect the worker from harmful exposure. The engineer may have to design local exhaust or general ventilation equipment which includes or takes responsibility for hood design, duct layout, and fan and air-cleaner selection in

Equipment frequently used in the Industrial Hygiene Laboratory includes: (1) air velometer; (2) electrostatic precipitator; (3) Bausch and Lomb dust counter; (4) halogenated hydrocarbon analyzer; (5) molecular filter assembly; (6) mercury vapor detector; (7) carbon monoxide tester; and (8) midget impinger and bubbler units.

new construction. Air cleaners are required when radioisotopes and unusually toxic materials are handled. The ventilation of highly flammable materials, such as ether and other combustible gases and vapors, have presented complicated problems. In co-operation with the Institute Safety Engineer, the industrial hygiene engineer provides consultation on correct selection of respirators, appropriate gas masks, and air lines or self-contained breathing apparatus, as may be most appropriate for the character of the work. The engineer gives advice throughout the Institute on problems of occupational stress involved in correct lighting, atmospheric pollution in the neighborhood, and discomfort and fatigue from environmental conditions.

In the evaluation of the work of the industrial hygiene engineer and chemist, it is clear that the chemist must indicate to the engineer where corrective ventilation and protection devices are needed by measuring air levels of toxic materials. The engineer then provides solutions and helps to execute necessary changes which are reviewed by the chemist to be certain of their adequacy. These facts are stressed to emphasize the dependency of one skill on another in prevention of worker injury.

There is considerable interest in basic and applied research involving radioactivity at M.I.T. This may be easily inferred from the table indicating the extent of radiation sources at M.I.T. The principal activities of the Radiological Safety Group can be divided into two categories – advisory and services.

Radiation Sources and Distribution, M.I.T.

Radioisotope Shipments from Atomic Energy Commission
(January-December 8, 1952)

Department	*Number of Shipments*	*Total Activity (in millicuries)*
Sanitary Engineering	25	232
Metallurgy	18	58
Physics	6	152
Chemistry	5	70
Biology	1	1
	55	513

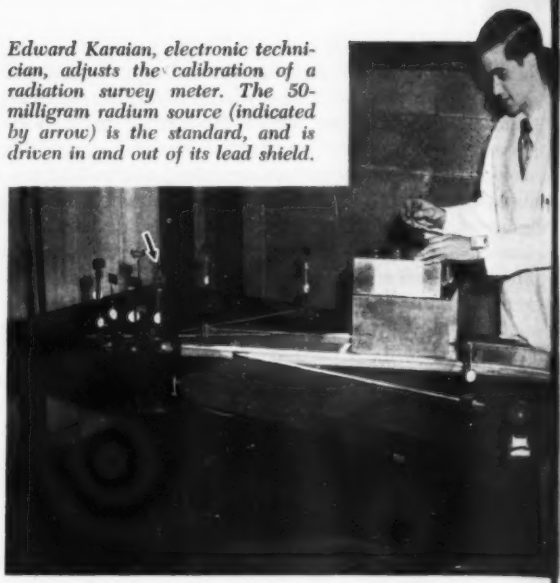
M.I.T. Laboratories Using Radioisotopes
(1952)

Number of Laboratories	*Activity Used*
2	Curies
12	Millicuries
25	Microcuries

Particle Accelerators at M.I.T.

Type	*Particle*	*Maximum Energy (Mev)*
Synchrotron	Electron	300
Linear Accelerator	Electron	30
Cyclotron	Deuteron	15
Generators (8 Van de Graaff)	Electron, Proton, Deuteron	1 to 12

Among other types of radiation-producing machines at M.I.T. are 25 x-ray diffraction units.



Edward Karaian, electronic technician, adjusts the calibration of a radiation survey meter. The 50-milligram radium source (indicated by arrow) is the standard, and is driven in and out of its lead shield.

The advisory phase is intended to insure that adequate consideration is given to radiological safety during the planning stages of an experiment. It is found that procurement and safe handling of radioisotopes and laboratory design are usually the areas in which safety advice is needed. An important point is that the Institute policy for the procurement of isotopes requires that all requests are approved by the Radiological Safety Officer. This requirement provides for the necessary advance notification to allow adequate time for a review of plans and a discussion of the problems.

The service category is concerned with the film badge program, instrumentation, laboratory survey, air sampling, waste disposal, and records. The service phase is intended to insure that the radiation workers' exposure is kept within permissible limits.

The film badge program provides continuous measurement and recording of personnel exposure to external radiation. At present there are approximately 300 persons on the film badge list. Each week the badges are collected and processed and the results reported.

The instrumentation service provides maintenance, calibration, and distribution of the many radiation detection instruments used by the workers to monitor their own exposure.

The laboratory survey program consists of periodic measurements at all laboratories using radioisotopes.

The air-sampling program consists of periodic sampling in laboratories where it is possible that atmospheric contamination may be evolved. In addition, breathing zone samples are taken when indicated to check operational exposures.

The waste disposal service provides for: (1) collection of radioactive wastes; (2) storage of such wastes in the concrete "igloo" (remote from operating personnel and research activities); and (3) proper disposal.

Complete records of personnel exposure are necessary, both for the protection of the worker and of the Institute.

(Continued on page 328)

Raymond E. Hanson

Project Glacier

By E. H. CAMERON

Our typical forebear who settled New England was a Jack-of-all-trades, each of which he mastered to a working degree of proficiency. He had to, to survive. His primary vocation was that of an agriculturist – he was a farmer. Even at the late date of our first census (1790),*[1] as many as 19 out of 20 Americans lived in rural communities.[2] Many of them lived in the regions where, aeons earlier, the great ice sheet that had capped much of the Northern Hemisphere had left its glacial mark. The glacial area in America was bounded[3] on the south by a line stretching from Manhattan Island to the Ohio River, and extending to the southerly section of the Missouri River. In New England the rocky, glacial record is the most pronounced. Because of this, the Yankee settler, after his tree chopping, stump removal, and brush burning, found that he faced still another task before planting and cultivation could start.

Except in the alluvial meadows, where Mother Nature had graciously deposited layers of rich loam, he had further to process his soil before he could plant it. There were the glacial stones – great rocks that had to be plowed around; two-man and one-man boulders that he and the older sons had to dispose of; and the smaller stones for the boys to pick out of the otherwise fertile soil. The boys knew that they could never win at this boy-chore; stones seemed to grow just as speedily as corn, wheat, or rye, for the spring plowing would turn up another crop of stones in the field they had faithfully cleared a season earlier. The boys would be taught that the Biblical parable of the sower said that "stony places"[4] were bad for growing things. They might get a more striking lesson, too, when their father would break his crude hoe or plow on a rock they had missed, for father's farming tools were not rugged. Because of the scarcity of iron and the high cost of imported tools, he had to make most of his agricultural implements himself – largely out of wood.

At the start, his hoe might have been the shoulder blade of a moose, bear, or deer,[5] strapped to a wooden pole – a trick he had learned from the Indians – and he had no plow. In the year 1637, all Massachusetts owned only 37 plows, and when plows became more common, they were neighborhood affairs, owned by a man who would be given a town bounty[6] to go from farm to farm to perform the plowing and who would charge the owner of the farm for the service. The share of his plow was of precious wrought iron, hung in crude fashion from the wooden beam above. Its mouldboard, for turning the share-cut earth into furrows, was well named, for it was literally made of boards – oak, hickory, or pine. Occasionally, the mouldboard was sheathed with scraps of old saw plate, or sheet iron.[6] The early American plow was thus a weak device, and it is significant that, before he could collect his bounty, the plowman had to prove his ability to keep his plow in repair. Therefore, stones, large and small, had to be cleared from the fields before plowing could start. So our ancestor, necessarily alert for ways to save time and muscular effort in his arduous program of living, decided to kill two birds with one stone – or, rather, many stones.

His own ancestors, who had settled Plymouth, had started under a planned community arrangement[7] that closely fits the definition of modern communism. Held to this arrangement by their agreement with the merchant adventurers who financed them, the Pilgrims found communal living very irksome, and soon devised ways to modify it, to allow each family to have its own farm and to benefit from the profits therefrom.[8] Thus, from the beginning, the New England settlers not only liked to have deeds to define the titles to their lands, but to have visible signs of ownership.†[9] The stone wall was the answer. The rocks would be loaded on a drag, probably made of stout saplings, fastened together with rope or by hickory pegs. The drag would be drawn between stumps and projecting ledge outcrops by oxen with crudely shaped wooden yokes, or perhaps, by horses with hemp, flax, or, in rare cases, leather harness. The boulders from the fields were transported thus to the property line. Rich landowners might have the line laid out by a surveyor, with his rather inaccurate compass; probably more often, the line would be located by a "foot-and-eye" survey. Then, the hard work of building the stone wall began, and a modern poet has aptly appraised the physical energy involved in this operation – "If ye only knew the backaches in an old stun' wall."‡ Primarily a farmer, our ancestor added the new trade of stonemason to his incidental trades of textile worker (processing the flax and wool from which his wife would spin and weave the linsey-

*[1] Please see numbered references at end of article, page 321.

† Deeds exhibited in Pilgrim Hall, Plymouth, date from 1644 on.

‡ Holman Day, *An Old Stun' Wall.*

woolsey for clothing); woodworker (operating his shingle-"frow," and two-man pit saw);[10] carpenter, saltmaker, cooper, and fisherman.

Almost anywhere he scratched the surface soil – the organic material of rotted vegetation deposited in the millenniums since the glacial era – our forebear struck stones. They were good stones, which had endured for many centuries the destructive forces of erosion, and the rupturing stresses caused by temperature changes. Removed from the soil so that cultivation could start, they made stout stone walls along lot lines, highways, and lanes; and encompassed many gardens, graveyards, and pastures. There were stones left over for cellar walls, survey merestones, crude arches over gullies, well linings, horseblocks, and bridge abutments, in this period of settlement, when the usual masonry structure was adapted to fit the uncut, unfinished stones that were available. Structures constructed of stones cut to specific dimensions were comparatively rare.

We must ask the geologist whence came all these stones. He will tell us, briefly, that in the latest of the epochs of geological time (the Pleistocene epoch)[11] a period of low temperature ensued, which encased most of the northerly parts of the earth with an icecap, often of mountainous height. Below the snow line, in the summer months, the ice would partially melt and glaciers would drift down the valleys, southerly, at velocities of a few inches or a few feet per day, according to local conditions. The movement of glaciers, hundreds of feet high, was of tremendous momentum, and in their path the glaciers would pluck off projecting ledges from mountains, and would thus carry enormous volumes of debris – rocks, and eroded sands. The top moraine would be of angular rocks with rounded corners. Rocks at the bottom, rolled for hundreds of miles through the long centuries, would become somewhat spherical (fieldstones) by the time they were finally deposited in the terminal moraine at the southerly end of the glacier. A valuable by-product of these processes of erosion and abrasion was the huge tonnage of sand that the glacier deposited.

The settler thus had a wide assortment of stones to pick from as he built his stone walls. As a stonemason his task was to build a structure of "dry masonry"; that is, his wall had to be an assembly of stones which must be stable, without the aid of mortar to fill the voids caused by the irregular shapes of the stones from which he had to choose. He became both artisan and engineer, having to supplement his manual dexterity and strength with the intelligence that told him how to place his stones. He was an engineer in embryo, of course, and he would call his decision not to waste much time on the bearing value of the foundation of his wall a matter of common sense. He might scrape off a few inches of topsoil and throw it into the field that the wall was to surround, for good growing soil was scarce.

He worried little about the frost line. If his wall settled a bit, and a precariously balanced top stone rolled off, he could easily replace it the next spring. He would place the heavier stones at the bottom, in the area he had scraped of topsoil – it was easier that way. By trial and error in the building of his first stone wall, he would learn that the ratio of the base width to the height of his wall was important. Tall walls called for wider bases. Common sense also solved the problem of stability – the keeping of the resultant of the vertical and horizontal loads safely within the base – without benefit of vector diagrams. In fact, the horizontal forces were incidental – they could result from the impact of a lusty bull or stallion that might try to leap over the wall occasionally, or from the disturbance of a clumsy bear that would try to scale it. If the beast failed in his attempt, an incipient failure by shear would be indicated; except that the top stone would exercise its right to overcome rolling friction and topple off, and the stability of the wall would not suffer. Well-bedded, base stones of suitable width were a prime requisite.

Stones of more or less parallel "bed" and "build" were at a premium. Not only would they stay put themselves, but they would assist the upper stone to remain in position. The too numerous, rounded field stones were not popular, but the builder would learn, by the principles of balance and friction, to make the stones of his wall mutually sustaining. It was obvious that a vertical joint in an upper course must not align with that of a lower one; that is, the joints must be "staggered." It was also clever to tuck the rounded end of a stone against an adjacent stone which, luckily, had an overhang; that is, joints should be "keyed" wherever practicable.

The schedule of progress of the wall-building ancestor was uncertain. There would be interruptions: a bear, tracked in the vicinity, demanded investigation; the sudden warning that Indians were near called for the corralling of family and beasts in the palisade-guarded fort. Indians were not interested in stone walls. A modern historian has unearthed the information that one rod of stone wall per day was average progress for a team of two men and a yoke of oxen.§ This information is obviously too conservative. At this rate, the construction of the boundary and incidental walls of an average New England farm might require years of the time of a settler and his oldest son. Time was too important, and the walls required for the farm would weigh only a few thousand tons – an easy burden for our stout ancestor.

The maintenance of his stone walls was a routine, spring operation of our forebear, before his neat cattle could be released to the pasture from their long, winter sojourn in the barn. Especially in sections near a brook, where the subsoil might hold water, the alternate freezing and thawing of the soil beneath would disturb the fine balance of stone-on-stone; and repairs to the wall and improvements on its original design would be necessary. Crevasses between stones in other wall locations might become filled with soil that would hold water and freeze, heaving the stones above. A son might have pried loose a stone, critical to the wall's balance, to allow his dog to get at a woodchuck. Many things could happen, which made it prudent to mend the walls periodically. Withal they were stout stone walls, which would last for centuries.

§ Haydn S. Pearson, "New England's Stone Walls Are Going!" *The Rural New Yorker*, September 16, 1950.

We can picture the pride of creation of the builder when a wall was finished. He would walk to its end and sight along its rounded top. Except for the brownish color, characteristic of rocks that have recently been unearthed, it would look like it had been built at the same time the adjoining gray, weathered stone wall had been built. It would be in good alignment as to line and grade. Its construction was an art, which had required strong muscles and skill — an art now almost forgotten. The settler would nurse his back muscles and hope that he was not developing a crick, from which so many of the older men of his generation of hard workers suffered. "It is my wall," he would say, "and mine are the fields that it encompasses."

With thousands of his fellows, he had given glacial New England a most durable record of the stamina of the forebears who settled it. Unless the modern agricultural trend succeeds in dooming the walls, because of the increased efficiency of the larger fields that their removal would provide,‖ our stone walls will continue to be one of our most valuable heritages. The archaeologists of the future will study the traces of our walls, and ponder. Humble in their cross-sectional dimensions of width and height, their linear dimension is tremendous. The aggregate length of the stone walls of New England has been estimated at 500,000 miles!#

If they are astute, the archaeologists will recognize the stone walls as artifacts of the first stage of civilized American culture that succeeded the semibarbaric culture of the American Indian. They will deduce that, like the Indians, the American settlers built their structures largely by man power, and will pay tribute to the physical stamina of the builders.

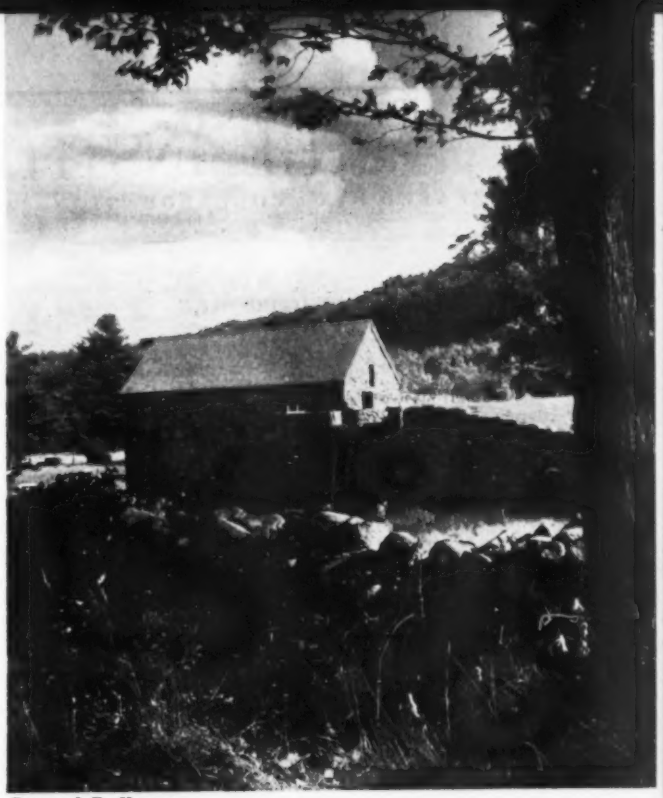
Following through with their research, the archaeologists will select, as the most impressive relics of the succeeding stage of American culture, the long tangents and geometric curves of our railroad cuts and embankments. That vastly more than human energy was required to move the huge quantities of sand, gravel, and hardpan such long distances for railroad cut and fill will be obvious to the archaeologists; and they will find evidence that animal power was beginning to be replaced by steam power in the era of railroad development.

The outstanding evidence of the third stage of structural development, of course, will be our modern, mammoth power dams, constructed either of earth or concrete. Happily, the archaeologists will find strange devices of this period of ponderous construction equipment, driven by crude (to them) machines termed electric motors and internal combustion engines.

The archaeologists will note the vastly improved efficiency of the still ancient devices that followed — all driven by the subtle power released by atomic fission. (New to us of 1953, atomic power will be old stuff to them.) These devices, too, will appear crude as they compare them with the ultraefficient means of construction in their own generation many centuries in our future.

‖ *See also*, "Hedgerow Trees," in *The Field*, *April* 19, 1952, London, England. This article deplores the uprooting of the English hedgerow trees, in a similar trend for "efficiency and mechanisation.

Editorial in Boston *Herald*, August 31, 1952.



Raymond E. Hanson

The grist mill at Sudbury, Mass., shows that natural stone was used for structures other than fences.

Reviewing their research through the millenniums, they will probably grant the highest accolade to those who started the chain reaction of American construction progress with their man-made stone walls and equally impressive contemporary structures. In their undeveloped country, our ancestors' determination to survive adequately overcame the deficiencies of their working tools whereby they got clothing, shelter, and enough to eat.

From the celestial area, reserved for those who built the enduring stone walls of New England, our forebear will observe the efforts of future students to understand them, and he will smile. "I just built those stone walls so that I and my working family could grow enough to eat," he will say. "True, we had to mend them every spring before we could put the cows out to pasture. But I used to read my Bible, and I know that my walls did not fall down, like the Walls of Jericho, which fell down seven days after they were attacked. Some folks, they say, got a tax abatement for clearing land, measured by the rods of stone walls they had built. We just got the fun of building ours — I and my strong sons."[12]

References

1. *Historical Statistics of the United States, 1789-1945*, page 25 (U.S. Department of Commerce, Bureau of the Census, 1949). In 1790 the rural population was 3,727,559, and the urban, 201,655 — a total of 3,929,214.

2. *Ibid.*, page 16. "Urban" was defined as incorporated places over 2,500 population.

(*Concluded on page 336*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Science and Civilized Man

JACOB BRONOWSKI, distinguished British scientist and man of letters, has been appointed Carnegie Visiting Professor of History at M.I.T. for the spring term. A noted exponent of scientific humanism. Dr. Bronowski will offer courses on the philosophy and history of science from this point of view in the School of Humanities and Social Studies. While at the Institute he will also give three public lectures on this theme, entitled "Science and the Civilized Man."

Polish born and English trained, Dr. Bronowski has an unusual combination of scientific and literary interests. He took first honors in mathematics at the University of Cambridge in 1930, and received the degrees of master of arts and doctor of philosophy there in 1933. He has published numerous papers in algebraic geometry and topology, and more recently in mathematical statistics. Since leaving university teaching in 1942 for wartime research, he has held government posts of increasing responsibility.

Dr. Bronowski has written two widely known books on literature: *William Blake: A Man Without A Mask* and *The Poet's Defence*. He is well known for his radio talks and dramas, one of which recently won the Italia Prize as the best dramatic work broadcast in Europe in 1950 and 1951. His most recent book, *The Common Sense of Science*, reinterprets the development of scientific ideas in terms of scientific humanism. He is planning a sequel to this book.

Biologist Honored

FRANCIS O. SCHMITT, Head of the Department of Biology at M.I.T., is one of 49 distinguished scientists who have been elected to Fellowship in the New York Academy of Sciences. Dr. Schmitt had been nominated to Fellowship by the Council of the Academy in recognition of his outstanding scientific achievements.

Internationally recognized as a leader in modern biological research, Dr. Schmitt has utilized the x-ray, polarized light, the electron microscope, and other tools and techniques of experimental physics in fundamental biological research.

He is especially noted for his research on tissue metabolism, the chemistry and physiology of nerves and connective tissue, ultrasonic radiation, surface phenomena, mono and multifilms, analysis of molecular ultrastructure of nerves and tissue cells by x-ray diffraction, polarized light and light-reflection methods, and research with the electron microscope.

The New York Academy of Sciences, organized in 1817, is the fourth oldest scientific society in the United States and its present membership is located in all 48 states, the District of Columbia, and in many foreign countries.

Lecture Platform

A GROUP of distinguished scholars from foreign nations will deliver a series of lectures at M.I.T. this spring while guests of, or visitors to, the Institute. Among the scholars who have already been in residence at the Institute – and whose lectures form a part of the spring program – are the Honourable Arthur Tyndall, '24, of New Zealand, Max Stoll of Geneva, and Andre J. Guinier of Paris who will deliver the Robert S. Williams Lectures.

The Honourable Arthur Tyndall, Judge of the Court of Arbitration of New Zealand, has been appointed visiting lecturer in the Department of Economics and Social Science at M.I.T., it was announced by John E. Burchard, '23, Dean of the School of Humanities and Social Studies.

Mr. Justice Tyndall arrived in the United States on February 27 for a six weeks' visit under the sponsorship of M.I.T. While at the Institute he will give a series of lectures based on his distinguished background of experiences as Senior Justice of the Court of Arbitration of New Zealand, a post which he has held since 1940. Early in his career he won the Bayliss Prize of the Institution of Civil Engineers, London, in the examination for associate membership.

Max Stoll, Director of the Research Department at Firmenich and Company of Geneva, Switzerland, delivered two lectures at the Institute late in February. Dr. Stoll, who is widely recognized for research in the field of aromatic chemistry, will receive the 1953 Fritzsche Award of the American Chemical Society while in the United States.

On February 24, under the auspices of the Department of Food Technology, Dr. Stoll spoke on "New Analyses and Organic Syntheses of Flavor and Odor Components" in Huntington Hall. The following day, under the auspices of the Department of Chemistry, Dr. Stoll spoke on a "General Survey of the Preparation of Megacyclic Musks."

Andre J. Guinier of the National Conservatory of Paris delivered the 1953 Robert S. Williams Lectures in the Department of Metallurgy at M.I.T. on March 10, 11, and 12. Dr. Guinier, who is Visiting Lecturer in Applied Science at Harvard University this spring, is internationally known for his work in the field of x-rays and metallurgy. He is professor at the Sorbonne and is codirector of the testing laboratory in the *Conservatoire des Arts et Metiers*.

In his lectures at M.I.T. on March 10 and 11, Dr. Guinier spoke on "Precipitation Phenomena in Supersaturated Alloys"; his lecture on March 12, sponsored jointly with the Department of Physics, dealt with "Recent Progress in X-ray Crystallography."

These Robert S. Williams Lectures continue the annual series of the Department of Metallurgy, in honor of the first head of the Department.

Industrial History

EXPLORATIONS in industrial history, designed to reveal the significant sweep of technological change, will soon be undertaken at the M.I.T. School of Industrial Management, according to E. P. Brooks, '17, Dean of the School. This field of study will be under the direction of Elting E. Morison, now Associate Professor of English in the School of Humanities and Social Studies, who will join the faculty of the School of Industrial Management next July as associate professor of industrial history. Professor Morison is widely known as the editor of *The Letters of Theodore Roosevelt*. In making this announcement Dean Brooks said:

The new history study will take into consideration the past of this country and, within these national limits, concentrate on the history of science, technology and industrial development, including the influence of industry upon our political and social organization. The emphasis on American industry is not meant to preclude instruction and research on the experience of other countries in which industry has been a determining influence.

A field of special interest will be the significant sweep of technological change. This is a process, involving as it does the direct and indirect results of industrial development on American life, that should be closely examined.

It is important that we know what are the causes of change, under what conditions change accelerates or slows down, who assists it, who resists it, how "good" changes are selected and "bad" changes rejected, how socially and administratively the necessary accommodations to change are made. If change is found to be the essential fact of our industrial society, we should know more about it and seek ways of preparing men to solve new problems.

In discussing plans for the program, Professor Morison said:

The general intent should be to discover, first, what the thing we call industry is, how it works, what it is like to live in it, what it looks like to those outside of it. And it will be interesting to find out wherever possible how industry has affected the shape, feelings, hopes, fears, and the daily life of the society it has produced.

A native of Milwaukee, Wis., where he was born in 1909, Professor Morison received the degree of bachelor of arts from Harvard University in 1932 and his master's degree in 1937. During World War II he served as a lieutenant commander in the United States Naval Reserve, and was consultant to the Research and Development Board of the Department of Defense from 1946 to 1952. Professor Morison has been a member of the Institute's Faculty since 1946, and has served since 1948 as director of the Theodore Roosevelt Research Project, under which eight volumes of President Roosevelt's letters have been published."

Class Reunions

Not as capricious as spring, when this issue of The Review comes to hand, are the plans which have evolved for class get-togethers and reunions to be held in conjunction with Alumni Day on Monday, June 15, and on other dates. The classes listed will hold reunions at the places indicated:

1893 Tentative plans for a meeting on the M.I.T. Campus early in June. Leonard B. Buchanan, reunion chairman, Stone and Webster, Inc., 49 Federal Street, Boston.

1898 Plans are tentative for 55th reunion. Full information will be in May Review. Lester D. Gardner, reunion chairman, 875 West End Avenue, New York 25, N. Y.

1900 June 16–18. The Pines, Cotuit, Mass. Elbert G. Allen, Secretary, 11 Richfield Road, West Newton, Mass.

1903 June 12–15. June 12, participation in commencement exercises; June 13 and 14, 50th reunion celebration at Coonamessett Ranch Inn, North Falmouth, Mass.; June 15, participation in Alumni Day events. Carlton F. Green, reunion chairman, Stone and Webster, Inc., 49 Federal Street, Boston.

1908 June 12–14. Snow Inn, Harwich Port, Mass. H. Leston Carter, reunion chairman, 14 Roslyn Road, Waban 68, Mass.

1911 June 19–21. Informal get-together at Snow Inn, Harwich Port, Mass.

1913 June 12–14. Oyster Harbors Club, Osterville, Mass. William R. Mattson, reunion chairman, 28 Brookdale Road, Newtonville 60, Mass.

1918 June 12–14. Weekapaug Inn, Weekapaug, R. I. Reunion chairmen: Max Seltzer, 87 Ivy Street, Brookline, Mass.; Saxton W. Fletcher, 880 North Street, White Plains, N. Y.

1921 June 15. Class cocktail party at Hotel Statler, Boston, preceding Alumni Banquet.

1923 June 11–14. Sheldon House, Pine Orchard, Conn. Channing P. Clapp, reunion chairman, 210 Main Street, Matawan, N.J.

1928 June 12–15. 25th reunion at Baker House, M.I.T., Cambridge, June 12–14. Participation in Alumni Day events, June 15. William H. Carlisle, Jr., reunion chairman, Room 5-121, M.I.T., Cambridge.

1933 June 12–14. Wentworth by the Sea, Portsmouth, N.H. Charles C. Bell, Universal Winding Company, Elmwood Avenue, Cranston, R. I.

1938 June 12–14. Curtis Hotel, Lenox, Mass. A. Louis Bruneau, Jr., reunion chairman, 412 Ponfield Place, Ridgewood, N. J.

1943 June 12–14. Mayflower Hotel, Plymouth, Mass. James F. Hoey, Jr., reunion chairman, 1826 Center Street, West Roxbury 32, Mass.

1948 June 13–14. Mayflower Hotel, Plymouth, Mass. Richard H. Harris, reunion chairman, 26 South Street, Grafton, Mass.

For the latest and more detailed information, please consult your Class Notes column, class secretary, or reunion chairman so that you may make satisfactory arrangements for attendance at your class reunion and on Alumni Day, June 15.

Food and Legislation

For the 118 members and guests who attended the 294th meeting of the Alumni Council on March 2, major topics of discussion were the dilemma of world food supplies, and labor legislation of the 83d Congress. In the absence of Edwin D. Ryer, '20, President of the Alumni Association, the meeting at the Faculty Club was called to order by Hugh S. Ferguson, '23, Vice-president.

During the business portion of the meeting, Donald P. Severance, '38, Secretary, announced that Arthur B. Cram, '80, would observe his 100th birthday anniversary on March 13, and that officers of the Administration and the Alumni Association planned to take recognition of this unusual occasion by sending congratulatory messages to be delivered to Mr. Cram by members of the Detroit M.I.T. Association. The Secretary also reported that, between January 27 and February 25, visits had been made to 19 alumni clubs by 19 members of the M.I.T. Administration or members of the Alumni Council. Such visits took members of the Technology family as far afield as Guatemala — where a new club has just been organized — Mexico City, Monterrey, and Montreal.

As Director of the Alumni Fund, Henry B. Kane, '24, reported that, as of March 2, slightly more than 8,000 Alumni had contributed $166,625 to the Alumni Fund for the current year. These figures represent increases of about 30 per cent over last year's figures of comparable data, both as to amount contributed and number of contributors.

Robert L. Johnson, '38, chairman of the Association's Committee on the Boston Luncheon Club, reported that attendance at the monthly meetings had increased from an average of 35, a year ago, to an average of 65 this year. He invited Alumni in Metropolitan Boston to attend meetings at the Union Oyster House at noon on the third Thursday of the month, when members of the M.I.T. staff would speak.

Karl T. Compton, chairman of the M.I.T. Corporation, reported on the successful afternoon and evening meeting of the M.I.T. Club of New York held on February 25. About 400 persons attended this meeting at the American Museum of Natural History, and heard Faculty members discuss different phases of "A Day in the Future." Dr. Compton also made brief mention of the current activity at the Institute where a number of meetings were being held by Visiting Committees, and the Institute's budget for the coming year was in preparation.

In speaking on the "The Dilemma of World Food Supplies," Robert S. Harris, '28, Professor of Biochemistry of Nutrition, placed a Twentieth Century point of view on the Malthusian theory. Studies in the nutritional quality of diets have taken Dr. Harris to Honduras, Ecuador, and Mexico, as well as to various parts of the United States. With the world's population tending to increase geometrically, Professor Harris believes that greater attention should be directed to increasing the nutritive qualities of diets normally found in various portions of the world. Good nutrition depends more on having the proper chemical constituents in food consumed, rather than upon adopting a specific dietary; thus adequate nutrition can be supplied by a wide variety of diets. This point of view assumes considerable practical importance when it becomes necessary, as it has in the past, for nations in one part of the world to assume responsibility for feeding persons in other regions. It was Professor Harris' plea that greater attention be given in the future, than has been extended in the past, to the strong personal preferences for locally produced foods, and the natural reluctance to eat unfamiliar foodstuffs. Finally, since arable land does not come under cultivation as rapidly as population expands, Dr. Harris pointed out that dietaries consisting largely of grain and other plants (such as those of the Asiatics) require less land to produce the same caloric requirements as do meat dietaries, and hence are more efficient, or at least more economical of land.

Douglass V. Brown, Alfred P. Sloan Professor of Industrial Management, concluded the meeting with a talk on labor legislation and the 83d Congress. Dr. Brown reviewed the basic features of a number of labor bills before Congress. He indicated his belief that in enacting any new legislation at this session, Congress would pursue a "middle of the road" policy rather than adopting either extreme; that no major changes in labor legislation are to be looked for in spite of the change in administration; and that the effect of any legislation which is enacted would probably depend not so much upon the actual provisions of any act as upon the general atmosphere of good will or vindictiveness which exists when the legislation is enacted.

Commencement Speaker

Lewis W. Douglas, '17, former U. S. Ambassador to Great Britain, will deliver the principal commencement address at the Institute this June. Mr. Douglas, a graduate of Amherst and a member of the Class of 1917 at M.I.T., has had a rich and varied career as legislator, public administrator, ambassador, and business executive.

He has been a member of the Arizona House of Representatives and the U. S. Congress. A former Director of the Budget, he served during World War II as war shipping administrator. During World War I, he received a citation from General John J. Pershing, and was decorated with Belgium's *Croix de Guerre* for service in the Argonne and Flanders. Mr. Douglas is a former vice-president and member of the Board of the American Cyanamid Company, and past president of the Mutual Life Insurance Company of New York where he has been chairman of the Board since 1947.

George B. Haven: 1871-1953

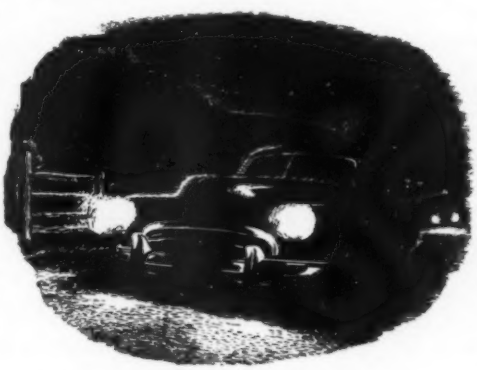
With regret The Review records the death, on March 6, of George B. Haven, '94, Professor of Advanced Machine Design, Emeritus, in the Department of Mechanical Engineering at M.I.T. Widely known as a leader in the design of textile machinery, Professor Haven was the author of numerous articles and books on textile research, and had served as consultant to several textile machinery firms.

(*Concluded on page 328*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Those of us who can remember the automobiles and trucks of twenty or thirty years ago find ourselves amazed as we drive down the road, or walk along the street. Today's cars are so immeasurably superior to those we saw, and some of which we owned, years ago. For a long time the automobile industry ha been notable for a number of vital contributions. It has put our whole nation on wheels, and has created a modern means of transportation that is so essential that the term "pleasure car" vanished long ago. It has provided employment for millions of us, not only directly in automobile factories, but directly and indirectly in the plants of suppliers of materials and parts, in garages, filling stations, road building, and so on.



Style changes often tend to obscure these economic aspects of the industry, and also to conceal the very real and sometimes amazing mechanical improvements that have been made. Once upon a time the automobile was a noisy, odorous, dirty and difficult contraption, whose owner had to go through a ritual of hand-starting, and be expert in emergency repairs. Women did not dare tackle it. Today it is quiet, clean, reliable, supremely easy to handle since many functions are performed automatically, so reliable that trouble raises eyebrows, and as comfortable as the living room sofa. You might call it a home on wheels. Women drive it as well as men, and neither needs to know what goes on in the chassis.

Years ago a tire manufacturer astounded the country by a guarantee of 5,000 miles; today it is common for a set of tires to go 25,000 miles and more. Carbureters, ignition, combustion chambers and compression have been greatly improved for gas economy and smooth running. The electrical system is a public utility in miniature. Engine cooling is automatic and so is interior heating. Power steering, power brakes and automatic transmissions greatly reduce the effort of driving. You could expand this list many times just by studying the new cars in the light of the old.

What brought all this about? You might say, and properly, that it was made possible by the genius of designers, engineers and production men. But there are other factors. One is the eagerness of the American people to own good cars; to many the automobile is essential, and as a nation we always want the best. Another element has been competition, the American way of business life. More automobile companies have failed than have succeeded; those who survived did so by offering more for the money. After all, in the long run sales are the public response to value.

To us at Revere the automobile industry is a source of great satisfaction, because our sales to it run at a high level. The modern car contains copper and copper alloys in vital parts, the largest single item being the radiator. Our aluminum alloys are also growing in importance in the automotive field. Thus when we buy and drive the 1953 models we have a double feeling of gratitude, first for the really magnificent things they are. And, second for the fact that in all probability they contain pounds and pounds of Revere Metals which through their unique characteristics contribute to the reliable performance we have come to take as a matter of course in our cars.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

***Executive Offices:* 230 Park Avenue, New York 17, N. Y.**

SEE REVERE'S "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

What General Electric people are saying . . .

I. F. KINNARD

Mr. Kinnard, with GE since 1922, is manager of the Engineering, Meter, and Instrument Department.

". . . The importance of development engineering to business and industry in general can hardly be overestimated. Successful development engineers are constantly bringing along new products for a new age.

Sometimes developments occur in time-tested and proved products, where they are least expected. Over the past half century G.E. has produced many millions of watthour meters. They have undergone a gradual evolution and refinement so that many considered this a barren field indeed for the development engineer. Yet, as recently as 1948, a completely new watthour meter was developed. It successfully employed for the first time in the engineering world the principle of magnetic suspension of a rotating part. The maintenance-free life of the meter was increased manyfold by this development—a development that was the product of close collaboration of development engineers and materials specialists, particularly metallurgists working on new permanent magnet alloys.

An important part of the development engineer's job is to take that believed to be possible and prove it practical. And in doing this job, he contributes significantly to the evolution of new and better products for a constantly rising standard of living. And whether he realizes it or not, he is one of the vital links in our American economy. His developments are helping to win acceptance throughout the world for the kind of system that brings them forth.

General Electric Review

J. E. BURKE

Dr. Burke is manager of the Metallurgy Section of the Knolls Atomic Power Laboratory

". . . Nuclear reactors are new, but many of the design problems facing the metallurgist are strictly old-fashioned. Such properties as strength, formability, thermal conductivity, resistance to corrosion at high temperatures, and of course, cost and availability, are as important in controlling the selection of materials for nuclear reactors as they are in controlling the selection of materials for other applications.

In addition to these properties, however, it is necessary to consider the interaction of the materials with neutrons. Everything enclosed in the heart of the reactor interacts to some extent with the neutrons, and a very careful control of materials that are included in the reactor is thus necessary.

Since vanadium appeared to be a possible material for use in nuclear reactors, a program to investigate its properties was undertaken several years ago. Although nominally pure vanadium had been available for a number of years, it was brittle and could not be fabricated. Some ductile vanadium had been prepared by calcium reduction of the oxide, but only beads and small pellets were produced. In improving this product, additions of iodine were made to the mixture of V_2O_5 and calcium. Upon heating this charge in a closed pressure vessel, the additional heat provided by the combination of iodine and calcium raised the temperature enough so that a large ductile button of vanadium was obtained. Unfortunately, subsequent runs yielded buttons that were brittle. After extensive investigation it was finally found that the brittleness was due to nitride in the oxide, and the final procedure used involved a careful denitriding of the vanadium oxide by heating in moist oxygen for several hours. The product as now produced can be rolled into thin foil, drawn to wire, or given any of the standard metallurgical treatments except hot working. Because it avidly absorbs oxygen to become brittle, it cannot be heated in air.

There are, of course, a vast number of other metallurgical problems encountered. As in other fields, improvements in materials are imperative if important advances in reactors are to be made. These require continuing work not only directly in the development of better materials but also on the fundamental studies that pave the way for the applied developments.

General Electric Review

C. W. LaPIERRE

Mr. LaPierre is a Company vice president and is general manager of the Aircraft Gas Turbine Division

". . . In 1952 the Aircraft Gas Turbine Division produced over 90% more engines than it did in 1951. And with this increase in production, the General Electric Company became the world's largest known producer of jet engines.

This all-time production high came as a climax to the Company's observance of the "Fastest Ten Years in History" which saluted the decade of aviation progress from 1942 to the end of 1952 . . . from the running of America's first turbojet, the General Electric I-A, to the development of today's advanced turbojets . . . from the flight of the first Bell P-59 to the tremendous speeds of the latest military aircraft.

As the first American designer and manufacturer of jet engines, we at G.E. feel that the expanded need for jet aircraft has justified our pioneering in the field of jet power plants.

In the commercial jet field, G.E. has two engines certified for commercial transports at the present time, the first certification being obtained in 1949. With this background, and the flight experience of thousands of jet engines now flying over Korea and elsewhere, there is no doubt in my mind but that an excellent, economical, American jet engine will be ready for commercial transports by the time the transports are ready to receive them.

Cincinnati, Ohio

You can put your confidence in—

GENERAL ELECTRIC

ME...
an AIRCRAFT engineer?

But I haven't majored in aeronautical engineering

That doesn't matter. Lockheed can train you... at full pay!

It's your aptitude, your knowledge of engineering principles, your degree in engineering that count.

Those—plus the opportunity Lockheed is offering you—are all you need for a career as an aircraft engineer. In Lockheed's special program for engineering graduates, you may go back to school, or you may convert to aircraft work by doing—on-the-job training. But whichever it is, you receive full pay while learning.

But Lockheed offers you more than a career. It offers you a new life, in an area where living conditions are beyond compare. Outdoor living prevails the year-'round. Mountains, beaches are an hour from Lockheed.

See your Placement Officer today for the details on Lockheed's Aircraft Training Program for engineers, as well as the better living conditions in Southern California.

If your Placement Officer is out of the illustrated brochures describing living and working conditions at Lockheed, write M. V. Mattson, Employment Manager

Lockheed Aircraft Corporation
Burbank, California

This Plane made History

The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

This Plane is making History

The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

This Plane will make History

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.

HEVI DUTY

Precision Electric Heat Treat Furnaces *(Laboratory and Industrial)*

Dry Type Air Cooled Transformers *(to 1000 KVA)*

Constant Current Regulators *(Static Type)*

Many nationally known laboratories and manufacturing plants use Hevi Duty Electric Heat Treating Furnaces where maximum performance is desired.

Hevi Duty specialty transformers are used extensively in the electrical control of industrial machinery and plant power distribution.

Airport and street lighting have been made safer and maintenance costs have been reduced through the use of Hevi Duty static type Constant Current Regulators.

Write for descriptive bulletins

HEVI DUTY ELECTRIC COMPANY

HEVI DUTY

HEAT TREATING FURNACES • ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS—CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

Harold E. Koch, '22, President
Elton E. Staples, '26, Vice President

THE INSTITUTE GAZETTE

(*Concluded from page 324*)

Professor Haven was born on April 28, 1871, in Sangerfield, N. Y., and in 1894 received the degree of bachelor of science from M.I.T. He then joined the Institute staff as an assistant in mechanical engineering. Two years later Professor Haven was promoted to instructor; in 1903, assistant professor; in 1910, associate professor; and in 1914, professor of machine design. He was named professor of advanced machine design and head of textile research in 1929, and seven years later retired to become emeritus professor of advanced machine design. In 1932, Professor Haven was awarded the silver medal of the National Association of Cotton Manufacturers.

AN M.I.T. ENTERPRISE IN OCCUPATIONAL HEALTH

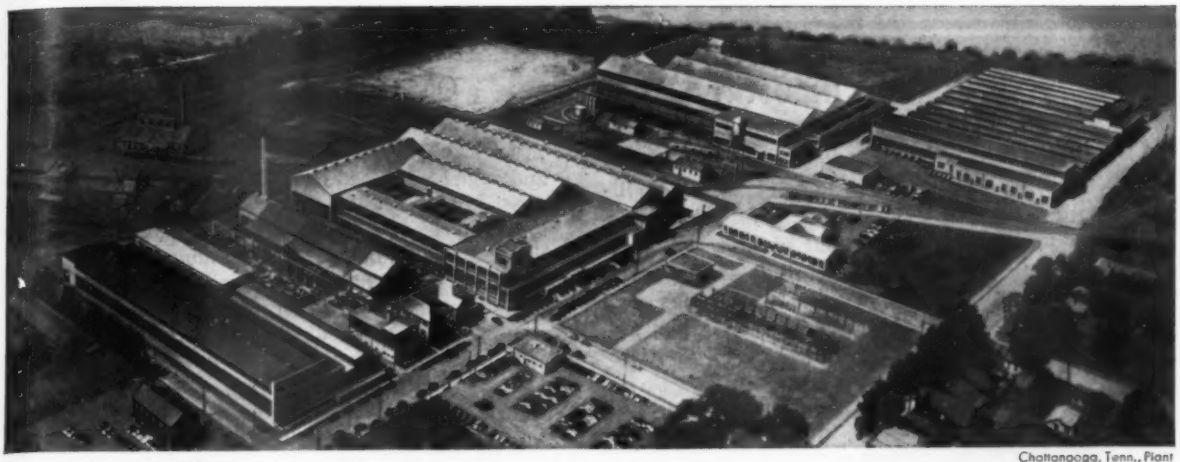
(*Continued from page 318*)

It might appear that the work of the group on radiological safety is entirely separate from that of the engineer and the chemist, but this has not proved to be the case. All three techniques are needed in the persistently difficult problem of safe disposal of toxic and explosive chemicals and dusts and radioactive materials.

One may wonder what the physicians can contribute to the Occupational Medical Service, for the preventive aspects of occupational health have been given first position and stressed in this discussion. In large measure the physicians of the Occupational Medical Service are preventive medical officers in a praiseworthy and fairly modern phase of medicine. By medical examinations at the time of placement, the physicians try to be certain that no staff member or worker approaching a potentially harmful exposure will find a current medical problem aggravated by his work or be harmed by ignorance of what his work entails. Chest x-rays, base-line repeated blood counts and, complete medical histories are examined. It should be emphasized that no one is kept from a job because of medical findings, with the exception of active carriers of contagious diseases. All medical findings are confidential between the physician and the individual who is told what is found and given relevant corrective suggestions.

The physicians are informed on the special effects of excess exposures to toxic chemicals, harmful dusts, and excessive radiation, and they work with the other Medical Department physicians as individual cases arise. Interpretation of chest x-rays and blood counts, in special groups of workers, and correlation of these data with measurement of air-toxicity radiation are further examples of the interdependence of the members of the Occupational Medical Service and the close relationship of this group as a whole to the Medical Department. Actual experience has brought us mercury effect, pulmonary edema from an irritant gas, x-ray burn of the hand, beryllium intoxication,

(*Continued on page 330*)



Chattanooga, Tenn., Plant

50% capacity increase at these COMBUSTION Plants

East Chicago, Ind., Plant

Expansion of facilities has been the order of the day for years past at Combustion's plants in Chattanooga, Monongahela, Chicago, East Chicago and St. Louis. This expansion has been necessary to meet the ever increasing demand for the company's line of boilers and related equipment resulting from the vast growth of the power industry both in the United States and abroad.

Today, with the company's backlog of orders at an all-time high, an accelerated program of expansion is well under way at the company's two largest plants—Chattanooga and East Chicago. This multi-million dollar program, begun early in 1952 and scheduled for completion by mid-1953, will effect a 50 per cent increase in the production capacity of these two plants. This increase will add nearly six acres of manufacturing area fully equipped with the most modern machine tools and special fabricating facilities.

With these added facilities, Combustion will be able to further expedite its delivery of boilers and related equipment for all power, process and heating applications in unit capacities from 2500 pounds of steam per hour up to the largest utility requirements.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT

B-636

C-E

COMBUSTION ENGINEERING—SUPERHEATER, INC.

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

FOR ALL INDUSTRY

Diefendorf makes gears for every industrial need—military and civilian—but always on specification—all materials—all types and sizes—to any required tolerance.

Diefendorf engineering help has served many leading industries in design and production problems.

DIEFENDORF GEAR CORP.
920 W. Belden Ave.
Syracuse, N. Y.

DIEFENDORF GEARS

specialists in prefabricating pipe

Albert's Prefabrication meets the most exacting specifications for Oil, Chemical, Concrete, Asphalt, and other Industrial requirements.

Butt Welds • Bending All Types • Coiling • Machining • Threading • Beveling • Lining • Pickling • Galvanizing • Sand Blasting • Preheating • Stress Relieving • Testing •

Pipe—Wrought Iron-Steel • Seamless • Electric Weld • Spiral Weld • Lap Weld • Butt Weld • Shore Dredge • SPEED-LAY •

Piling — Sheet piling-lightweight-Tubular all sizes.

Pile Fittings — All types and sizes for steel and wood.

Write for Free Prefabrication Booklet.

S. G. ALBERT '29

ALBERT pipe supply co., inc. BERRY AT NORTH 13TH ST. • BROOKLYN 11, N. Y.

AN M.I.T. ENTERPRISE IN OCCUPATIONAL HEALTH

(*Continued from page 328*)

and toluene-induced narcosis as problems calling for special handling. The total quantity of work of purely service character done by the Occupational Medical Service totals about 900 visits annually in the two years for which figures are available. Roughly, half of these visits are made for medical consultations and examinations of various kinds, and the other half are field visits of the technical staff to laboratories where toxic materials are in use.

If industry understands the dangers to health and safety involved in handling this or that material, it will know how to prevent such tragedies as the deaths of young women engaged in using red phosphorus in making matches. Thus, in many ways, the teaching of Institute students, who in the future will have important industrial posts, is the most exciting function of the Occupational Medical Service. For the most part this teaching is informal to individuals and to single classes on invitation by instructors. Thus far, the Departments of Chemistry, Physics, Metallurgy, Food Technology, Electrical Engineering, and the Sloan School of Industrial Management have asked our co-operation.

In 1952, at the request of Rolf Eliassen, '32, Professor of Sanitary Engineering (and with help from the members of the Department of Industrial Hygiene of the Harvard School of Public Health), the Occupational Medical Service gave a course in Industrial Hygiene for credit to a class of graduate students. As experience and skill are gained, a remarkable opportunity becomes apparent to awaken M.I.T. students, at graduate and undergraduate levels, to the knowledge available in the field of prevention of occupational illness and accident. As Dr. Alice Hamilton pointed out 20 years ago, if the technical men going into industry know the facts of hazardous exposure much industrial illness can be prevented.

Finally, we believe that a lively department of high professional excellence will wish to carry on some investigation while leading its daily life of service, and will manage to find the time for this. The Occupational Medical Service has many questions it wants to study. As opportunities arise, the staff will address itself to questions such as the following, some of which are already being studied now: the factors involved in the vaporization of mercury; absorption factors involved in evaluating radioactive aerosols collected by filter-paper techniques; a volatile filter as a collection for chemical, weight, surface area, and particle-size analysis; determination of uranium in air by various collecting mediums, and comparison between radioactive counting and fluorometric methods of analysis; development of method and study of urinary execution of strontium;[90] study of the incidence of binucleated lymphocytes in the Institute community; further study of the clinical aspects of beryllium effect, and long-term study of changes in the blood elements in workers exposed to low-level

(*Concluded on page 332*)

RCA NEEDS ENGINEERS

who won't be held back!

RCA, pioneer and leader in every important branch of radio-electronics, has a permanent position for you if you are an experienced ELECTRONIC, COMPUTER, ELECTRICAL, MECHANICAL OR COMMUNICATIONS ENGINEER . . . PHYSICIST . . . METALLURGIST . . . PHYSICAL CHEMIST . . . CERAMIST . . . GLASS TECHNOLOGIST.

You may choose to specialize in research, development, design and application. Both commercial and defense projects.

POSITIONS OPEN IN RESEARCH— DEVELOPMENT—DESIGN—APPLICATION

in any of the following fields:

RADAR—
Circuitry—Antenna Design—Servo Systems—Information Display Systems—Gear Trains—Stable Elements—Intricate Mechanisms

COMPUTERS—
Digital and Analog—Systems Planning—Storage Technique—Circuitry—Servo Mechanisms—Assembly Design—High Speed Intricate Mechanisms

COMMUNICATIONS—
Microwave—Aviation—Mobile—Specialized Military Systems

MISSILE GUIDANCE—
Systems Planning and Design—Radar and Fire Control—Servo Mechanisms—Vibration and Shock Problems

NAVIGATIONAL AIDS—
Loran—Shoran—Altimeters—Airborne Radar

TELEVISION DEVELOPMENT—
Receivers—Transmitters and Studio Equipment

COMPONENT PARTS—
Transformer—Coil—Relay—Capacitor—Switch—Motor—Resistor

ELECTRONIC TUBE DEVELOPMENT—
Receiving—Transmitting—Cathode-Ray—Phototubes and Magnetrons

ELECTRONIC EQUIPMENT FIELD ENGINEERS—
Specialists for domestic and overseas assignment on military electronic communications and detection gear.

There's not a temporary job among them. War or depression, RCA has continued to grow . . . growth in which you'll share when you launch your lifetime RCA career.

For many other reasons, too, RCA is a *good* place for you to work. RCA affords unexcelled facilities in pleasant surroundings . . . every chance for advancement in rank and income . . . enjoyable suburban or country living conditions . . . *professional recognition* for achievement . . . modern retirement program. Many Company-paid benefits for you and the family. PLUS modern tuition-refund plan for advanced study at recognized universities.

Personal interviews arranged in your city.

If you qualify for any of the positions listed above, please send us a complete resume of your education and experience. Please state your specialized field preference. Send resume to:

MR. ROBERT E. McQUISTON, Manager
Specialized Employment Division,
Dept. 206D,
Radio Corporation of America,
30 Rockefeller Plaza, New York 20, N.Y.

RADIO CORPORATION of AMERICA

NEWTON WALTHAM WATERTOWN
RIGHT HERE
(near Cambridge)
AT RAYTHEON
QUINCY BEDFORD
you may well establish
YOUR CAREER IN ENGINEERING

Research and development opportunities abound in the great and growing fields of

RADAR	KLYSTRONS
ELECTRON TUBES	TRANSISTORS
CATHODE RAY TUBES	SERVOMECHANISMS
COMMUNICATIONS	COMPUTERS
GUIDED MISSILES	ULTRASONICS
MAGNETRONS	UNDERWATER SOUND

PRODUCTION,
QUALITY CONTROL, DESIGN, AND AUTOMATION

BOOKLET— picturing and describing the many and varied Raytheon career opportunities may be picked up at the M.I.T. Placement Office, Room 1-173, or will be mailed on request.

RAYTHEON MANUFACTURING COMPANY
WALTHAM 54, MASSACHUSETTS

Rate Measuring
GYROSCOPES
for
Control
Stabilization
Flight Testing
Rate Computation

For the accurate measurement of absolute rates of angular rotation, the Doelcam Model K Rate Measuring Gyroscope offers the following features:

1. Accuracy: 0.5%
2. Resolution: 0.1%
3. Maximum uncertainty: 0.2%
4. Hermetically sealed
5. Shock and vibration resistant
6. Microsyn pickoff: 60 — 5,000 cps
7. Thermostatically controlled damping ratio
8. Small size: 3 inches diameter x 5.82 inches
9. Lightweight: 3 3/8 lbs.

The design of the Model K Gyroscope affords wide latitude in the adjustment of parameters and permits design to any particular specifications.

DOELCAM CORPORATION
56 Elmwood Street Newton 58, Massachusetts
GYROSCOPIC FLIGHT TEST AND CONTROL INSTRUMENTATION
SYNCHROS · SERVOMECHANISMS · MICROSYNS
ELECTRONIC INVERTERS

AN M.I.T. ENTERPRISE IN OCCUPATIONAL HEALTH

(Concluded from page 330)

radiation. There probably is not enough time or money in a lifetime for achieving all this.

In conclusion, a word or two may be in order regarding the staff, whose responsibilities have been outlined above.

Dr. Harriet L. Hardy, Assistant Medical Director in charge of the Occupational Medical Service, joined the Medical Department in the spring of 1949 to develop the preventive aspects of occupational medicine as needed by the Institute. After 10 years of medical practice, Dr. Hardy received three years' practical training in occupational disease with the Division of Occupational Hygiene of the Massachusetts Department of Labor and Industries during 1945-1948. During 1948, prior to coming to M.I.T., Dr. Hardy studied medical problems associated with radiation exposure as a staff member of the health division of the Los Alamos Scientific Laboratory.

Dr. Ivan D. Frantz, Jr., of the Huntington Memorial Group at the Massachusetts General Hospital, gives skillful service in the problems of the biological effects of radiation.

Dr. Albert O. Seeler, of the Atomic Energy Commission, formerly assistant professor of Industrial Medicine at Harvard, serves one day a week, providing medical supervision for workers exposed to unusual toxic hazards.

Samuel Levin, an Institute graduate of the Class of 1948, is the full-time physicist holding the position of Institute Radiological Safety Officer.

Frederick J. Viles, Jr., also an Institute alumnus (Class of 1938), with graduate training in the Department of Industrial Hygiene of the Harvard School of Public Health, and experience in industrial hygiene with the U. S. Navy, and the Liberty Mutual Insurance Company, was at first part-time and, since 1950, is full-time industrial hygiene engineer.

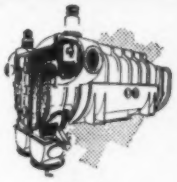
Miss Janet E. Walkley, trained as an industrial hygiene chemist, joined the Occupational Medical Service in 1950, after six years with the Employers Group.

From this discussion of the work being done, the reader will surely sense the great potential for preventative medical service and teaching of this happy enterprise placed, as it is, in the vigorous life of the Institute's Medical Department.

SCULLY SIGNAL COMPANY
Safe Fills } with VENTALARM®
No Spills } WHISTLING TANK FILL SIGNAL
for automotive, home and diesel fuel tanks

F. P. Scully '15 88 First St., Cambridge 41, Mass.
"JUST FILL 'TIL THE WHISTLE STOPS"

DID YOU KNOW?



1 . . . that you can Clean Condenser Tube Sheets without Downtime or Loss of Pressure?

C. H. Wheeler Reverse Flow Condensers are "Self-Cleaning". Electrically, hydraulically or manually operated sluice gates within the condenser reverse the flow of water in the tubes to flush debris and marine growth away from tube sheets.

2 . . . that there are Vacuum Pumps with No Moving Parts . . . and often requiring No Extra Power?

C. H. Wheeler Tubejets convert waste steam into useful vacuum for pumping, refrigeration, etc.

3 . . . that a Cooling Tower can be Built to Blend with a Building—or to Stand Alone against Hurricane Winds?

C. H. Wheeler Water Cooling Towers may be sheathed with any building material to harmonize with an architectural plan. Sturdy construction is guaranteed for performance and durability.

4 . . . that Material will Grind Itself into Particles 100 Times Finer than the Human Eye Can See?

C. H. Wheeler Fluid Energy Reduction Mills reduce materials to sub-micron particle sizes. Material is conveyed by air, steam or any gas or vapor in a closed circuit at supersonic speeds causing particles to reduce themselves by repeated shattering contact with one another.

Bulletins mailed on request.

C. H. WHEELER *of Philadelphia*

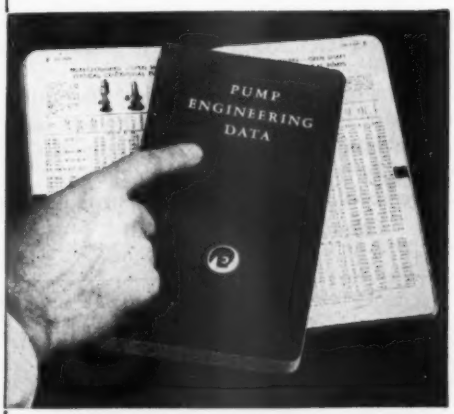
C. H. WHEELER MANUFACTURING CO., 19th & LEHIGH, PHILADELPHIA 32, PENNA.

Steam Condensers • Centrifugal, Axial and Mixed Flow Pumps • Steam Jet Ejectors • Cooling Towers • Vacuum Refrigeration
High Vacuum Process Equipment • Micro-Particle Reduction Mills • Marine Condensers and Ejectors • Deck Machinery

1952 PUMP ENGINEERING HANDBOOK

The Research Has Been Done For You

"PUMP ENGINEERING DATA" has been compiled for professional and student engineers who want their information in one volume. Designed for ease for use, with tables, diagrams, and charts.



• • • was assembled by experts to provide the most pertinent and up-to-date material for pump engineering. Substantially bound in maroon and gold—contains over 400 pages.

• • • covers pumping problems encountered in buildings, waterworks, sewage treatment plants, oil refineries, mines and quarries, irrigation, power plants, food and chemical plants, paper mills, and in many other applications.

Send today for your copy of
"PUMP ENGINEERING DATA" $3.00

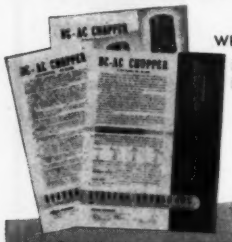
WHEELER-ECONOMY PUMPS

ECONOMY PUMPS, INC • Division of C. H. Wheeler Mfg. Co.
Sedgley at 19th and Lehigh • Philadelphia 32, Penna.

DC-AC CHOPPER

A model for every use — 60 and 400 cycles
Single pole and double pole — Make-before-break contacts — Contacts in air or in liquid

These Choppers convert low level DC into pulsating DC or AC, so that servo-mechanism error voltages and the output of thermocouples and strain gauges may be amplified by means of an AC rather than a DC amplifier. They are hermetically sealed, precision vibrators having special features which contribute to long life and low noise level.



WRITE FOR CATALOGS . .
#246B, 60 cycles, AC
#280, 400 cycles, AC

STEVENS-ARNOLD
INCORPORATED
77 ELKINS STREET, SOUTH BOSTON 27, MASS.

THE ORIGINAL SWING BOOM MOBILE CRANE WITH FRONT-WHEEL DRIVE AND REAR-WHEEL STEER

KRANE KAR

MOVES LOADS
EASIER - FASTER -
SLASHES COST OF
MATERIALS HANDLING

KRANE KAR handles loads at Sides as well as at Front.

Gas or Diesel. Pneumatic or solid rubber tires; 9 to 37 ft. booms or adjustable telescopic booms; electric magnet, clamshell bucket, and other accessories available.

At your service 24 hours every day because it is gasoline-powered (no layups for battery charging). Works inside and outside your plant. KRANE KAR serves also as an auxiliary to existing crane facilities . . . and as an emergency tool for plant maintenance. Let us show you. Ask for Bulletin No. 79 or for a Sales-Engineer.

1½, 2½, 5 and 10 ton capacities.

SILENT HOIST & CRANE CO.
891 63rd ST., BROOKLYN 20, N. Y.

Eric Martin Wunsch, II, '44 Jim Beach, II, '50

SCIENCE AND RELIGION

(*Continued from page 314*)

character experience only misery all their lives, while others who never do a worthy act are uniformly prosperous. This is the effect of chance. What can be said with certainty is that, if millions of individuals are considered, it will be found that in almost all cases those of better character are healthier, happier, and more prosperous. But since this is only a probability there are always some who follow the wrong course because they overestimate the chance of winning by wrong methods. These people are often not evil but, as Socrates so strongly emphasized, only ignorant. They are merely poor mathematicians.

Since right makes might, it is the object of politics, as well as of religion, to determine what is right. In some cases, for example homicide, the decision is simple. In others, the conclusion may be much less obvious. The difficulty is that right is often a complex of many factors. To determine the relative merits of two procedures it is necessary to assign weights to these factors, and any assignment of weights is arbitrary. A logical conclusion may therefore not be possible.

For example, Tacitus, the Roman historian, was much impressed with the rugged individualism of the Germans. Each citizen insisted on having a little piece of ground about his house, and was willing to support his leaders in war only when convinced in popular assembly. Tacitus hardly realized that these simple qualities made the German system better, and therefore ultimately stronger, than the collectivism of Rome.

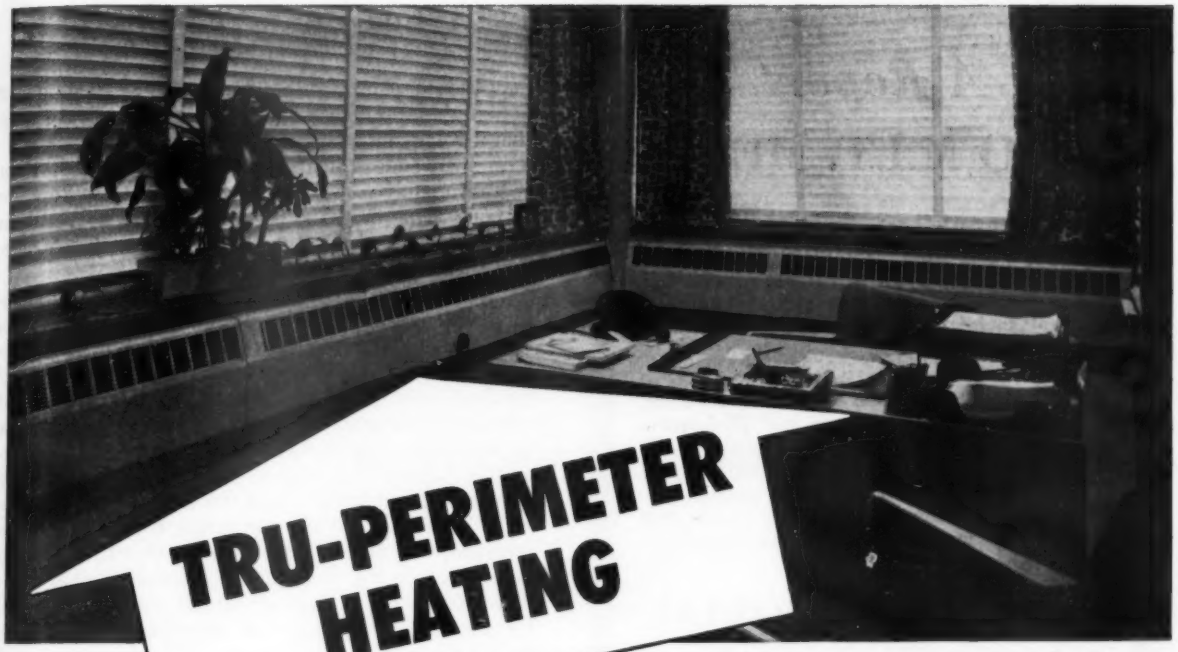
At present the world is largely ruled by two ideologies. In half the world it is believed that a small group of men can plan the daily lives of all the others. History, as well as reason, shows that this is not possible, even if the leaders are of the highest character and have the greatest ability. In the other half of the world, it is believed that the majority can plan for all the people. History and reason again indicate that this is impossible. In reality, neither of these methods of rule has ever been tested in practice. In autocracies, as well as in democracies, the government concerns itself only with a limited number of things. If two lists were made — one including the acts in which the government takes part, the other containing the acts left entirely to the individual — the list of individual acts would probably be longer even under the most autocratic government. The success of a particular state

(*Concluded on page 336*)

GEORGE W. McCREERY CO.

Building Construction

250 BOYLSTON STREET BOSTON, MASS.



Fully air-conditioned Physicians and Surgeons Building, Columbus, Ohio, uses Webster Walvector in perimeter heating to compensate for heat loss from large glass exposure

Webster Walvector, installed under the continuous windows and extending only about 3 inches from the wall, spreads the heat from wall to wall in the Physicians and Surgeons Building. A continuous flow of hot water is circulated, heated sufficiently to completely offset the effect of the cold glass, thereby assuring comfort *everywhere*.

Top heating efficiency is assured through the use of sturdy aluminum fins on copper tubing, spaced for maximum effectiveness. Enclosures with integral grilles are sturdily built of amply heavy steel. Heating elements and enclosures are both mounted on a heavy gauge mounting angle, sealed against the wall with a continuous sponge rubber seal preventing any air flow in back of the mounting or enclosure.

The list of advantages of Webster Perimeter Heating with Webster Walvector is a long one.

Complete technical data on Webster Walvector is available in Bulletin B-1551 and the experience of the 60-year old Webster organization is yours to call upon. Get in touch with your Webster Representative or write us.

Physicians and Surgeons Building, Columbus, Ohio. Completed 1951, features Webster Walvector and complete air-conditioning. Architect: Tibbals, Crumley and Musson. Consulting Engineer: Robert S. Curl and Associates. Heating Contractor: The Huffman Wolfe Company.

Address Dept. TR-4

WARREN WEBSTER & COMPANY
Camden 5, N. J. Representatives in Principal U. S. Cities
In Canada, Darling Brothers, Limited, Montreal

Webster
WALVECTOR
REG. U. S. PAT. OFF.
For Steam or Hot Water Heating

A Report

TO M.I.T. MEN

In 1917 Walker Memorial Building was opened, a gift from Alumni for the welfare of M.I.T. students. In addition to including offices for student activities and serving as a student social center, this building houses the dining service.

In 1951-52 nearly one million meals were served to staff and students and 57 dances, receptions and balls were held in Morss Hall. Morss Hall seats approximately 500 people. Thus, each chair served 2,000 people per year or 5.5 persons per day. We thank the Alumni for making these services possible.

WALKER MEMORIAL DINING SERVICE

• M.I.T. •

CAMBRIDGE 39, MASSACHUSETTS

A. W. BRIDGES, *Manager*

Fairfield & Ellis INSURANCE

Protection . . .

from every angle

WHATEVER your needs . . . whatever your size . . . wherever you are . . . have Fairfield & Ellis check your coverage to be sure it is completely realistic.

SIXTY CONGRESS STREET, BOSTON 9

SCIENCE AND RELIGION

(*Concluded from page 334*)

may then depend not on which of these ideologies it actually adopts, but on how much it neglects to put that ideology into practice.

In such confusion the only certainty is that right will ultimately prevail. Like the ancient Hebrew, we can only hope that God is on our side, or as Abraham Lincoln better phrased it, that we are on God's side, that is, that we are right.

Life may be considered a journey whose beginning was nothing, whose destination is infinity. On this journey we are not only passengers but also members of the crew. The course of life is probably fixed by the nature of the physical universe. The speed of advance is, however, influenced by our efforts. With a little change of pace during the Middle Ages, for example, George Washington might have had electric power and antibiotics, and we might have already visited the moon. While the future course cannot be foreseen, we can say with certainty that the most exciting part of the journey will always lie ahead. To increase the list of marvels which we ourselves will be permitted to see, it is then incumbent on each of us to live the good life, that is, to do his utmost to speed the journey onward.

PROJECT GLACIER

(*Concluded from page 321*)

3. *Nelson's Encyclopaedia*, 5:439.
4. Matthew 13:5.
5. *One Hundred Years' Progress of the United States*, page 21 (Hartford: L. Stebbins, 1871).
6. *Ibid.*, page 27.
7. Willison, George F., *Saints and Strangers*, pages 161, 162 (New York: Reynal and Hitchcock, 1945).
8. Willison, *op. cit.*, pages 192, 231, 232, 262.
9. Deeds in Pilgrim Hall, page 12 (1673), page 14 (1661, 1684), page 19 (1655), page 20 (1644, 1692). *Historical Collection and Pictures, Pilgrim Hall* (1930).
10. *Reference Guide to Salem*, 1630 (Pioneer Village).
11. Scott, William B., *Introduction to Geology*, 2d Ed., (New York: The Macmillan Company, 1908).
12. An old New Hampshire man vouches for the tax abatement. Research by several law libraries, however, fails to verify this statement.

THE MURRAY PRINTING COMPANY

A Complete Printing Organization Specializing in Book Reproduction

Wakefield • Massachusetts

to the

ELECTRICAL

ENGINEER

or

PHYSICIST

with experience in

RADAR

or

ELECTRONICS

Hughes Research and Development Laboratories, one of the nation's leading electronics organizations, are now creating a number of new openings in an important phase of their operations.

Here is what one of these positions offers you:

THE COMPANY

Hughes Research and Development Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar systems, electronic computers and guided missiles.

THE NEW OPENINGS

The positions are for men who will serve as technical advisors to government agencies and companies purchasing Hughes equipment—also as technical consultants with engineers of other companies working on associated equipment. Your specific job would be essentially to help insure successful operation of Hughes equipment in the field.

THE TRAINING

On joining our organization, you will work in the Laboratories for several months to become thoroughly familiar with the equipment which you will later help users to understand and properly employ. If you have already had radar or electronics experience, you will find this knowledge helpful in your new work.

WHERE YOU WORK

After your period of training—at full pay—you may (1) remain with the Laboratories in Southern California in an instructive or administrative capacity, (2) become the Hughes representative at a company where our equipment is being installed, or (3) be the Hughes representative at a military base in this country or overseas (single men only). Compensation is made for traveling and moving household effects, and married men keep their families with them at all times.

YOUR FUTURE

In one of these positions you will gain all-around experience that will increase your value to our organization as it further expands in the field of electronics. The next few years are certain to see large-scale commercial employment of electronic systems. Your training in and familiarity with the most advanced electronic techniques now will qualify you for even more important future positions.

How to apply:

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Scientific and Engineering Staff
Culver City,
Los Angeles County, California

If you are under thirty-five years of age, and if you have an E.E. or Physics degree, write to the Laboratories, giving resumé of your experience.

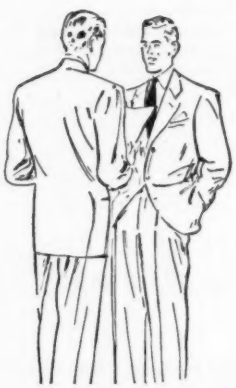
Assurance is required that relocation of the applicant will not cause disruption of an urgent military project.

SPRINGWEAVE

SUITS

WON'T LET YOUR APPEARANCE DOWN

NO MATTER HOW WARM IT GETS



Now you can *always* look smart . . . fresh . . . cool . . . and *feel* that way in a lightweight, non-wilt Springweave suit. For Springweaves . . . made of a new, wrinkle-resistant fabric . . . are also "tailored" to keep their fresh good looks in all weather. The patented Perma-Fold collar, for example, holds its perfect crease and "hug" even after laundering, cleaning, pressing, *and* you can wear a Springweave suit 9 months of the year.

$45

Select your Springwear Suit now, — you may pay for it when you take it. This arrangement has three advantages. The alterations will be made at once, the suit held, ready for delivery at a moment's notice, and you don't pay for it until you need it. Technology Store membership and charge cards accepted at The Harvard Square Store.

The COOP
Harvard Square Store

SOCIAL ASPECTS OF AERONAUTICS

(Continued from page 313)

and exclusive sovereignty over the airspace above its territory."

The exercise of sovereignty supposes some practical action for control and enforcement. It is not a purely academic question. It has long been held that the territory of a State is limited by the ability of that State to make its law effective. In the Seventeenth Century, a Dutch jurist (Bynkershoek) evolved from established practice the now generally accepted principle that "dominion seaward is limited to the extent to which it is possible to enforce it," a principle which created the concept of territorial waters and the three-mile limit (cannon-shot range).

This would be a harsh rule to apply to the airspace. Only a few great States have power to control the airspace above their surface territory. Weak States have no such power. But the possession of power does not determine international right. The ancient principle of unlimited sovereignty is becoming eroded in these times of interdependence, in favor of international agreements and the delegation to a United Nations Organization of powers once reserved to individual States.

Air Power

We seek security in our ability to control the airspace above us and to defend ourselves against an aggressor by early interception of his aircraft. The complex of resources needed to give a nation control of the airspace against a challenge is commonly called "air power." The term need not be defined in detail, but it includes as its foundation scientific and industrial resources adequate to create superior airplanes and weapons, as well as the Air Forces to use them. Air Forces are presently organized by function in accordance with the current ideas of military planners. These ideas change with technical progress, and the international climate.

The great nations are experiencing a period of extreme pressures on their economies and ways of life. At the same time, control of a new power to destroy one another has been given them. Aeronautics, the new tool of global transportation, offers new means to make war at a distance. By this very threat, it stimulates efforts to seek voluntary adjustments between nations to resolve their fears of one another.

(Continued on page 340)

William H. Coburn & Co.
INVESTMENT COUNSEL
68 Devonshire Street
Boston

Three great names combine to produce a completely revolutionary and amazing new shirting fabric that we call

BROOKSWEAVE*

in the first Dacron and cotton blend oxford shirt for men... it is porous, fast drying and requires no pressing

From Du Pont came Dacron†...and invaluable technical assistance. From Cone Mills, one of the largest and most modern in the country, came the spinning and weaving skill and know-how to produce this fine cloth. And from our own workrooms came the shirts themselves, made on our button-down collar style.

Made of a blend of Dacron and fine long staple cotton, Brooksweave shirting combines the soft, natural feel of our world-famous cotton oxfords, with all the magic qualities of Dacron. Months in the making, in the experimenting, and in the testing, it is, we believe, the finest and most practical shirt of its type ever produced. The Brooksweave shirt can be washed at night, hung on a hanger soaking wet and be dry, fresh looking and ready to wear the next morning. Here is the answer to laundering problems, both at home and while travelling.

Brooksweave is a world wide exclusive and is sold only at Brooks Brothers' stores or by our Travelling Representatives. In all sizes from 14-32 to 17½-36.

In White, on Our Famous Button-Down Collar Style, $12.50

ESTABLISHED 1818

Brooks Brothers

CLOTHING

Men's Furnishings, Hats & Shoes

NEW YORK • BOSTON • CHICAGO • LOS ANGELES • SAN FRANCISCO

Address Mail Orders to Dept. C, 346 Madison Avenue, New York 17, N. Y.

*The term Brooksweave is a trade mark of Brooks Brothers, Inc.

†Du Pont's polyester fiber

If You Need Additional Manufacturing Capacity

CALL IN

LIQUID's

CONTRACT MANUFACTURING DIVISION

◆ Capacity and manpower available on Machine Shop, Sheet Metal and Woodworking facilities for industrial or defense contracts.

Write for illustrated booklet "Special Contract Department" which lists and describes facilities.

Liquid *Contract Manufacturing Division*

THE LIQUID CARBONIC CORPORATION
3100 South Kedzie Ave. • Chicago 23, Illinois
Manufacturers of Brewing and Bottling Machinery, Soda Fountains, Gas Welding Equipment CO_2 Gas, Dry Ice, Oxygen and Medical Gases

PRECISION-GAUGED HAIRSPRINGS AND FINE ROLLED WIRE

PRECISION PRODUCTS COMPANY

WALTHAM, MASSACHUSETTS

ROBERT I. BRADLEY, '20

SOCIAL ASPECTS OF AERONAUTICS

(Continued from page 338)

International Society

Aeronautics can be a tool for the implementation of a world-wide regime of law and order. It facilitates the meetings of statesmen, the conduct of inspections and police action, and in general can serve for both surveillance and enforcement.

Professor William F. Ogburn has said that historians are reluctant to give credit to technology rather than to great men as a social force, while philosophers of history give all credit to ideas. Neither party can be entirely right.

Columbus discovered America and set in train a vast succession of social changes, but back of Columbus lay the technology of the ocean-going ship. Without Columbus some other European would have discovered the New World. The existence of the ship guaranteed it.

There is a propelling force in technology which drives great men and also constitutes the propelling force of ideas. For example, the idea of nationalism is powerful today. The territorial base for the modern State was laid by transportation inventions and consolidated by communications. Without them nationalism would be restricted to a very small area. Finally, the present international struggle, which is only accentuated nationalism, is based on the inventions of warfare, principally air power. Technology prepares the way for statesmen or for conquerors.

There is now a huge disproportion between human wisdom and human power. Perhaps the best fruits of the tree of knowledge are tools. The airplane of the Wright brothers has become the vehicle for a world-wide system of air transportation and, at the same time, it has been the means for the annihilation of cities.

There have been sermons on the good and the evil of new knowledge, and the dedicated research man is not unaware of the perils of his success. The airplane is just another tool to serve the purposes of mankind; whether for good or evil is determined by the user. The individual with an airplane is not a serious menace as he is controlled by the police power of the State. So is the individual with a torch or a motor car. The

(Concluded on page 342)

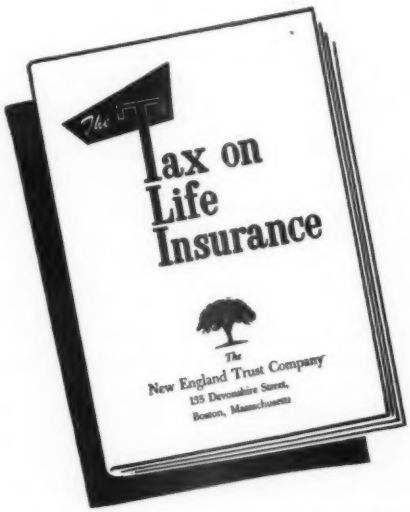
The TREDENNICK-BILLINGS CO.

Construction Managers — *Building Construction*

K. W. RICHARDS '07 — H. D. BILLINGS '10 — C. C. JONES '12 — F. J. CONTI '34

10 HIGH STREET — **BOSTON, MASSACHUSETTS**

Some Things YOU Should Know About The Tax on Your Life Insurance



Your life insurance is subject to the Federal estate tax just as are your securities, your real estate and your business interests.

The way you arrange your life insurance may increase or decrease the tax on your whole estate. This is particularly true since 1948 when the tax law first allowed a "marital deduction".

To minimize taxes, and to provide a better financial future for your family, it is essential that you integrate your life insurance into the plans you have made for distributing all your other assets—whether or not the other assets are jointly or individually owned.

We shall be glad to work with your lawyer and life underwriter in helping you work out such an overall estate plan.

We invite you to visit or write our Trust Department for a copy of our booklet, "The Tax on Life Insurance". It may help you conserve more of your life insurance for your beneficiaries.

The

New England Trust Company

135 DEVONSHIRE STREET

At the Corner of Milk Street

BACK BAY BRANCH : : 99 NEWBURY STREET

BOSTON, MASSACHUSETTS

Member Federal Reserve System

BANKING FOR modern NEW ENGLAND

SYSKA & HENNESSY, INC.
Engineers

DESIGN • CONSULTATION • REPORTS
POWER PLANT • WASTE DISPOSAL • WATER SYSTEMS
New York City

HOLMES & NARVER, INC.

ENGINEERS • CONSTRUCTORS
828 SOUTH FIGUEROA STREET
LOS ANGELES 17
TRINITY 8201

JAMES T. HOLMES
M.I.T. '14

D. LEE NARVER
STANFORD '14

CHAUNCY HALL SCHOOL

Founded 1828. The School that specializes in the preparation of students for the Massachusetts Institute of Technology.

Ray D. Farnsworth, *Principal* 533 Boylston Street, *Boston, Mass.*

LEONARD CONSTRUCTION COMPANY

Engineers and Contractors
SINCE 1905

IN THE AMERICAS AND FAR EAST

37 South Wabash Ave.
Chicago

SOCIAL ASPECTS OF AERONAUTICS

(Concluded from page 340)

complex apparatus of air power, however, is a tool of the State, to be used as its leaders may desire. In them we hope for wisdom. Complex societies are expected to produce social patterns capable of absorbing innovations. Our present international society is in the process of adjusting itself to the innovation of flight. The adjustment is painful, and the final pattern has not yet evolved.

In scientific research we have a kind of chain reaction. Research emits new knowledge whose applications confront us with new problems. These problems in turn excite new research with further new and perhaps unexpected results. The evolution of aeronautics has proceeded in this way on a wide front, and we may expect it to continue at an even more rapid rate. One may well expect that the effects of the advancing technology of flight will be substantial, with a consequent disturbance of the relatively static distribution of man and his works over the earth, as determined primarily by physical geography.

Geography has hitherto compartmented peoples in accordance with the physical features of land and sea, by climate zones, and cultural frontiers. Now we have mobility in a third dimension with which to reckon. The ocean of air provides highways from anywhere to everywhere. Geographical barriers, largely determined by older modes of transportation, are becoming unreal; they no longer give security nor prevent the interpenetration of ideas. An iron curtain is an artificial and socially expensive attempt to maintain a geographical status more appropriate to a previous century.

LICENSING ARRANGEMENTS WANTED

We wish to acquire patent rights on electrical components, instruments, or accessories used in the following fields:

RADIO, RADAR, OR TELEVISION. TELEPHONE, TELEGRAPH, TELETYPE, OR SOUND ON FILM. PUBLIC UTILITIES. AIRCRAFT.

Our preference is for items that have limited rather than mass markets. We have a particular interest in switches and relays, also in telephone parts and accessories.

All replies to be held confidential. Please write to Box G Technology Review. SA-3

N. A. LOUGEE & COMPANY
ENGINEERS AND CONSULTANTS

Reports—Appraisals—Depreciation Studies
Rate Cases—Business and Economic Studies

120 BROADWAY NEW YORK 5, N.Y.

N. A. LOUGEE '11 L. A. MATTHEWS '13
J. W. McDONALD, Jr. '20 B. F. THOMAS, Jr. '13
E. S. WEST '40

J. C. CORRIGAN CO., INC.
Conveyers

ENGINEERS • MANUFACTURERS • ERECTORS

Coal Handling Systems
Material Handling and Processing Equipment
Portable Conveyers

Distributors for
Jeffrey Manufacturing Co.
41 Norwood Street, Boston 22, Mass.
Tel. GEneva 6-0800

PROFESSIONAL CARDS

JACKSON & MORELAND

Engineers and Consultants

Design and Supervision of Construction
Reports — Examinations — Appraisals
Machine design — Technical Publications

BOSTON NEW YORK

JAMES F. DOWNEY

CONSULTING ENGINEER

INDUSTRIAL ORGANIZATION, PLANT LAYOUT, LABOR MEASUREMENT, JOB EVALUATION, PLANNING & SCHEDULING, MATERIAL CONTROL, BUDGET & COST CONTROL, LABOR RELATIONS

20 North Broadway White Plains, N.Y.

EADIE, FREUND AND CAMPBELL

CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 36, N. Y.

Mechanical — Electrical — Sanitary
Air Conditioning — Power — Process Layouts

J. K. Campbell, M.I.T. '11

STARKWEATHER ENGINEERING CO.

INCORPORATED

Engineers and Contractors for Pumping Plants
Boiler and Power Plants, Cooling Water
and Heat Recovery Systems

246 Walnut Street, Newtonville BI 4-8042

J. B. Starkweather, B.S. M.I.T. '21

THE KULJIAN CORPORATION

Consultants • Engineers • Constructors
UTILITY • INDUSTRIAL • CHEMICAL

1200 N. Broad St., Phila. 21, Pa.

MEXICO CITY • CARACAS • MADRID • ROME • ATHENS • TOKYO • CALCUTTA •

H. A. Kuljian '19 A. H. Kuljian '48

FABRIC RESEARCH LABORATORIES

Incorporated

Research, Development and Consultation
for Textile and Allied Industries

665 Boylston Street Boston, Mass.

W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

GILBERT ASSOCIATES, INC.

ENGINEERS AND CONSULTANTS

Malcolm G. Davis '25, *Vice President* Allen W. Reid '12 E. C. Edgar '35

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

New York, N. Y. Reading, Pa. Washington, D. C.
Philadelphia, Pa. Houston, Tex.

FAY, SPOFFORD & THORNDIKE

Engineers

Airports — Bridges — Water Supply and Sewerage
Port and Terminal Works — Fire Prevention

INVESTIGATIONS DESIGNS
SUPERVISION OF CONSTRUCTION

BOSTON NEW YORK

CLEVERDON, VARNEY & PIKE

Consulting Engineers

HERBERT S. CLEVERDON '10 WALDO F. PIKE '15

Structural Designs Foundations
Heating Ventilating and Plumbing Designs
Industrial Buildings, Reports, Investigations

120 TREMONT STREET BOSTON 8, MASS.

MAURICE A. REIDY

Consulting Engineer

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

Estimates and Appraisals

101 TREMONT STREET BOSTON, MASS.

CHARLES NELSON DEBES AND ASSOCIATES

ENGINEERS AND CONSULTANTS

Plant Layout—Electrical—Mechanical
Structural—Sanitary—Acoustical

ROCKFORD TRUST BLDG. ROCKFORD, ILL.

C. N. DEBES '35

MORAN, PROCTOR, MUESER & RUTLEDGE

CONSULTING ENGINEERS

Foundations for Buildings, Bridges and Dams;
Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

Pardo, Proctor, Freeman & Musser
Ingenieros Consultores
Ap. Correos 614, Caracas, Venezuela

WILLIAM H. MUESER '22
PHILIP C. RUTLEDGE '33

CHARLES A. MAGUIRE & ASSOCIATES

ENGINEERS

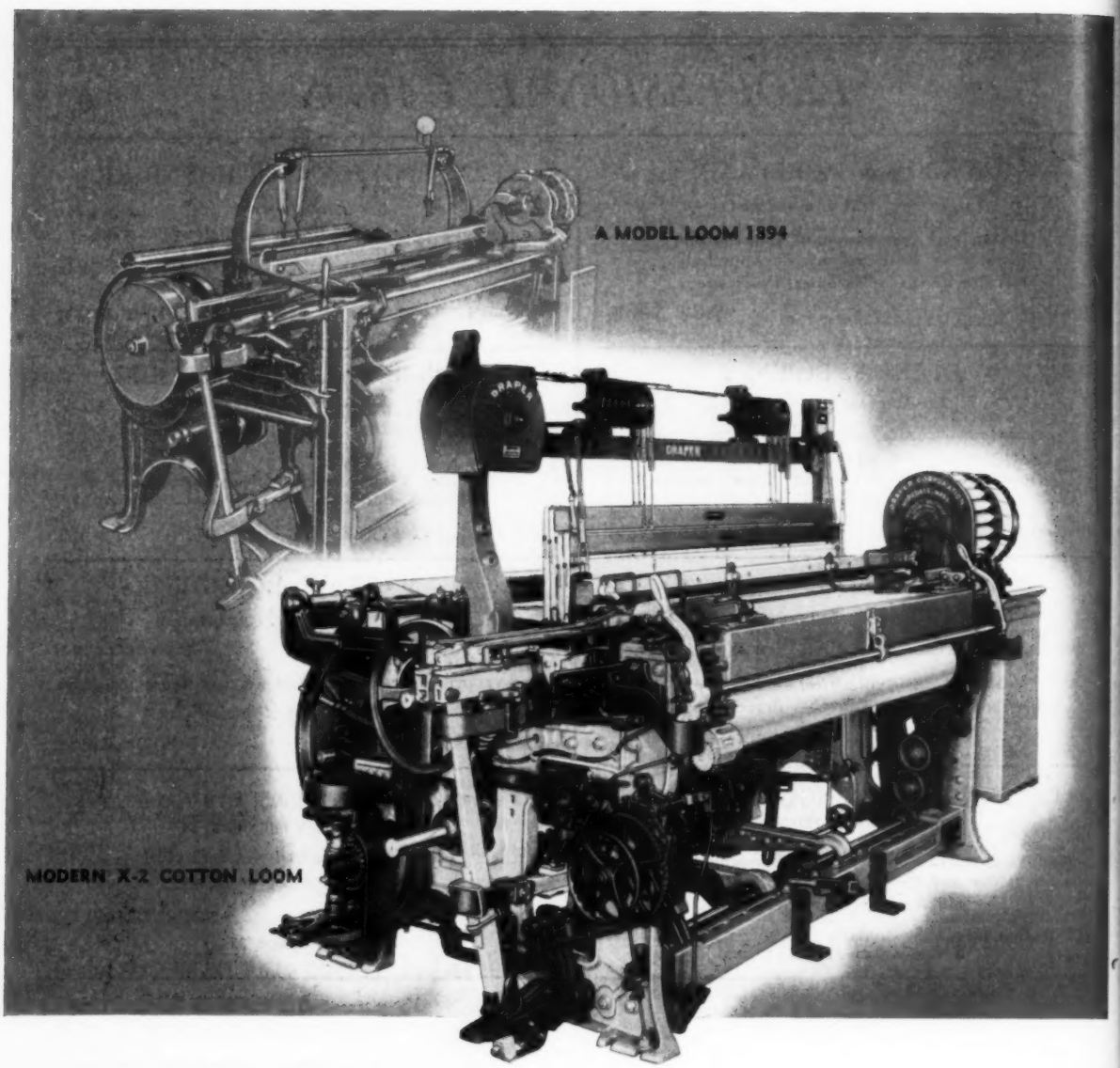
PROVIDENCE BOSTON

Cohasset 4-1020 Hingham 6-2360

FRANK MASSA

Electro-Acoustic Consultant

373 Atlantic Avenue 5 Fottler Road
Cohasset, Massachusetts Hingham, Massachusetts



Weaving Facts:

When the automatic loom was invented and developed by Draper engineers in 1894, mills having common looms could only assign four looms per weaver producing print cloth. The Draper automatic A Model enabled weavers to run eight looms each on this fabric.

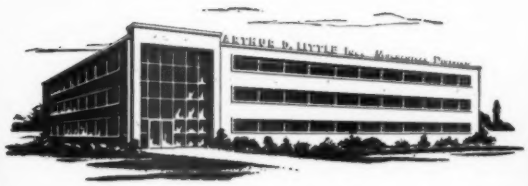
With the perfection of the Draper High Speed X-2, one weaver in a well run print cloth mill today is responsible for a set of over one hundred looms running considerably faster than the older looms.

Unlike single-fabric A Models, the X-2 is versatile weaving broadcloth, drills, twills, sheeting, gauze, piques, gabardine, and even Dobby fancies.

Draper Looms Produce More Cloth at Less Cost Throughout the World.

DRAPER CORPORATION

ATLANTA, GA. HOPEDALE, MASS. SPARTANBURG, S. C.



New ADL Mechanical Division Building

UNIQUE PROTOTYPE DEVELOPMENT

. . . using advanced Engineering Techniques

Design and construction of 400 gallon capacity vessels to contain liquefied gases near 400 degrees below zero F was a recent example of ADL prototype development.

Reducing costly evaporation losses took high-vacuum insulation at a pressure of 1 x 10^{-6} mm Hg, as well as knowledge in extreme low temperature engineering — even under severe transportation heat leaks of only 1/12 watt/sq. ft. occurred.

ADL experience in many areas of science and engineering produced this unique prototype.

IF lack of personnel has halted development of your new ideas or new products, the ADL Mechanical Division can take over and bring them to complete maturity.

Arthur D. Little, Inc., has blended its scientific and engineering skills in the Mechanical Division to provide industry with a unique service . . . prototype development of equipment requiring a high level of engineering. Scientists in the fields of chemistry, physics, metallurgy, mathematics, biology, electronics and technical economics can be called on as required.

Our staff is experienced in interpreting the ideas of industry and following through with the perfection of specialized equipment.

MODYNAMICS · HEAT TRANSFER · REFRIGERATION TO MINUS 456 F · VACUUM ENGINEERING · GAS LIQUEFACTION · ELECTROMAGNETISM · MECHANICAL DESIGN · VIBRATION

Write for Brochure TR16-1

MECHANICAL DIVISION

Arthur D. Little, Inc.

CREATIVE TECHNOLOGY SINCE 1886

ADL Mechanical Division

30 MEMORIAL DRIVE, CAMBRIDGE, 42, MASS.

All in One

Bridge Detector
UHF Standing-Wave Indicator
General Purpose Amplifier

Type 1231-B Amplifier and Null Detector is a battery-operated, resistance-coupled amplifier which may be used as a sensitive bridge detector, a general purpose laboratory amplifier, or as a standing-wave indicator at ultra-high frequencies.

This instrument can be operated either with the usual linear amplifier characteristic or with a semi-logarithmic characteristic which makes it useful as a sensitive visual null detector in bridge measurements. For linear operation, the voltmeter scale has two ranges of two volts and twenty volts, respectively. At the semi-logarithmic position, and at maximum gain, less than 15 microvolts will produce a perceptable meter deflection, while more than 4,500 microvolts are required to drive the meter off scale. A built-in vacuum-tube voltmeter measures output voltage; head telephones can be used for aural indication where preferable.

High sensitivity combined with wide voltage range permits bridge balance with precision and without bothersome gain adjustments.

Features

★ *Gain is greater than 70 db at 10 cycles and greater than 45 db at 100 kc — at midband (1 kc), maximum open-circuit voltage gain is greater than 83 db.*
★ *At "null detector" position, less than 100 microvolts input gives 10% indication on meter at 1 kc.*
★ *At "amplifier" position, less than 25 μv input at 1 kc gives 10% indication on sensitive range of meter.*
★ *Maximum output voltage is 5 volts into 20,000 ohms; 20 volts into 1 megohm.*
★ *Low noise level of 15 microvolts (referred to input) can be further reduced along with hum and harmonics, by connecting external filter to panel jack.*
★ *Input impedance is 1 megohm in parallel with 20 μμf. Output impedance is 50,000 ohms resistive.*
★ *Push buttons provide convenient operation of input attenuator, set the condition of operation, select the meter-scale range and check battery voltages.*
★ *Tubes are mounted on shock-absorbing suspension for minimum microphonic effects.*
★ *Type 1261-A Power Supply Unit can be used to operate the Type 1231-B from 40 to 60 cycle a-c lines; power supply fits into cabinet in place of battery.*

1231-BM Amplifier and Null Detector, Battery operated	$250.00
1231-BMA Amplifier and Null Detector, a-c operated	370.00
1231-P2 400 and 1000 cycle Filter	25.00
1231-P3 60 cycle Filter	20.00
1231-P5 Adjustable Filter (11 frequencies from 50 c. to 100 kc.)	215.00

At ultra-high frequencies, a slotted coaxial transmission line, such as the G-R Type 874-LB, is often used with a traveling crystal detector to measure standing-wave ratios. If the UHF power source is pulsed, or amplitude modulated at an audio-frequency rate, the rectified output may be amplified and detected by the Type 1231-B.

The most sensitive input range enables detection of 5 microvolts in the mid-frequency range. This sensitive range was incorporated into the instrument's vacuum-tube voltmeter specifically for this application.

GENERAL RADIO Company
275 Massachusetts Avenue, Cambridge 39, Massachusetts, U. S. A.
[illegible] NEW YORK 5 · 920 S. Michigan Ave. CHICAGO 5 · 1000 N. Seward St. LOS ANGELES 38

Admittance Meters ☆ Coaxial Elements ☆ Decade Capacitors
Decade Inductors ☆ Decade Resistors ☆ Distortion Meters
Frequency Meters ☆ Frequency Standards ☆ Geiger Counters
Impedance Bridges ☆ Modulation Meters ☆ Oscillators
Variacs ☆ Light Meters ☆ Megohmmeters ☆ Motor Controls
Noise Meters ☆ Null Detectors ☆ Precision Capacitors
Pulse Generators ☆ Signal Generators ☆ Vibration Meters ☆ Stroboscopes ☆ Wave Filters
U-H-F Measuring Equipment ☆ V-T Voltmeters ☆ Wave Analyzers ☆ Polariscopes